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For: SEMICONDUCTOR DEVICE	)

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VERIFICATION OF TRANSLATION

Sir:

I, Yumiko Takekoshi, C/O Semiconductor Energy Laboratory Co., Ltd. 398, Hase, Atsugi-shi, Kanagawa-ken 243-0036 Japan, a translator, herewith declare:

that I am well acquainted with both the Japanese and English Languages;

that I am the translator of the attached translation of the Japanese Patent Application No. 2000-245989 filed on August 14, 2000 and

that to the best of my knowledge and belief the followings is a true and correct translation of the Japanese Patent Application No. 2000-245989 filed on August 14, 2000

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: this 22nd day of February 2005

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[Attachment]	Abstract 1
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[Name of Document] Specification

[Title of the Invention]

SEMICONDUCTOR DEVICE

[Scope of Claim]

[Claim 1]

A semiconductor device characterized in that:

a first electrode;

an insulating film formed on said first electrode;

a contact hole which is provided in said insulating film and has a depth so as to reach said first electrode;

a gate wiring which is formed on said insulating film and connected with said first electrode through said contact hole;

a second electrode provided on said insulating film; and

a liquid crystal layer provided over said second electrode,

wherein said second electrode is provided so as to block an electric field by said first electrode to said liquid crystal layer.

[Claim 2]

A semiconductor device characterized in that:

a semiconductor film;

a gate insulating film provided on said semiconductor film;

a first electrode which is provided on said gate insulating film and overlaps said semiconductor film;

an insulating film formed on said first electrode;

a contact hole which is provided in said insulating film and has a depth so as to reach said first electrode;

a gate wiring which is formed on said insulating film and connected with said first electrode through said contact hole;

a second electrode provided on said insulating film; and

a liquid crystal layer provided over said second electrode,

wherein said second electrode is provided so as to block an electric field by said first electrode to said liquid crystal layer.

[Claim 3]

A semiconductor device characterized in that:

a first semiconductor film;

a second semiconductor film;

a gate insulating film provided on said first semiconductor film and said second semiconductor film;

a first electrode which is provided on said gate insulating film, intersects said first semiconductor film, and overlaps said second semiconductor film;

an insulating film formed on said first electrode;

a contact hole which is provided in said insulating film and has a depth so as to reach said first electrode;

a gate wiring which is formed on said insulating film and connected with said first electrode through said contact hole;

a second electrode provided on said insulating film; and

a liquid crystal layer provided over said second electrode,

wherein said second electrode is provided so as to block an electric field by said first electrode to said liquid crystal layer.

[Claim 4]

A semiconductor device characterized in that:

a first electrode;

an insulating film formed on said first electrode;

a contact hole which is provided in said insulating film and has a depth so as to reach said first electrode;

a gate wiring which is formed on said insulating film and connected with said first electrode through said contact hole; and

a second electrode provided on said insulating film and;

a liquid crystal layer provided over said second electrode,

wherein said first electrode is overlapped at 70 % or more of an area thereof with said second electrode

[Claim 5]

A semiconductor device characterized in that:

a semiconductor film;

a gate insulating film provided on said semiconductor film;

a first electrode which is provided on said gate insulating film and overlaps said semiconductor film;

an insulating film formed on said first electrode;

a contact hole which is provided in said insulating film and has a depth so as to reach said first electrode;

a gate wiring which is formed on said insulating film and connected with said first

electrode through said contact hole; and

a second electrode provided on said insulating film;

a liquid crystal layer provided over said second electrode,

wherein a storage capacitor is constructed by said first electrode, said gate insulating film, and said second semiconductor film and overlapped at 90 % or more of an area thereof with said second electrode.

[Claim 6]

semiconductor device characterized in that:

a first semiconductor film;

a second semiconductor film;

a gate insulating film provided on said first semiconductor film and said second semiconductor film;

a first electrode which is provided on said gate insulating film, intersects said first semiconductor film, and overlaps said second semiconductor film;

an insulating film formed on said first electrode;

a contact hole which is provided in said insulating film and has a depth so as to reach said first electrode;

a gate wiring which is formed on said insulating film and connected with said first electrode through said contact hole; and

a second electrode provided on said insulating film;

a liquid crystal layer provided over said second electrode,

wherein a storage capacitor is constructed by said first electrode, said gate insulating film, and said second semiconductor film and overlapped at 90 % or more of an area thereof with said second electrode.

[Claim 7]

A semiconductor device according to any one of claims 1 to 6, wherein a capacitor per an unit area of said insulating film is 0.018 [mF/m^2] or more.

[Claim 8]

A semiconductor device characterized in that:

a first electrode;

a second electrode provided on said insulating film

wherein said first electrode is overlapped at 70 % or more of an area thereof with said second electrode, and a capacitor per an unit area of said insulating film is 0.018 [mF/m^2] or more.

[Claim 9]

A semiconductor device characterized in that:

a storage capacitor is formed from a semiconductor film, a gate insulating film over the semiconductor film and a first electrode over said gate insulating film;

an insulating film over said storage capacitor has a capacitance of 0.018 [mF/m^2] or more per unit area; and

90 % or more of an area of said capacitor is overlapped with the second electrode that is formed over said insulating film.

[Claim 10]

A semiconductor device according to any one of claims 1 to 9, wherein a pixel electrode is formed on said insulating film and said second electrode is in contact with said pixel electrode.

[Claim 11]

A semiconductor device according to any one of claims 1 to 9, wherein said second

electrode is a pixel electrode.

[Claim 12]

A semiconductor device according to any one of claims 1 to 9, wherein said insulating film is formed by a first insulating film comprising an inorganic material and a second insulating film comprising an organic material

[Claim 13]

A semiconductor device according to any one of claims 1 to 9, wherein said semiconductor device is a reflection type electro-optical device.

[Claim 14]

A semiconductor device according to any one of claims 1 to 9, wherein said semiconductor device is a projection type electro-optical device.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention pertains]

The present invention relates to a semiconductor device having a circuit composed of thin film transistors (hereinafter referred to as a TFT) and to a method of manufacturing the same, for example, an electrooptical device which is represented by a liquid crystal display panel and an electronic equipment on which such an electrooptical device is mounted as a part.

[0002]

Note that the semiconductor device in this specification denotes devices in general, which can function by utilizing a semiconductor characteristic. The electrooptical device, a semiconductor circuit, and the electric equipment are entirely the semiconductor device.

[0003]

Also, note that an element substrate in this specification denotes a substrate in general, with which an element utilizing a semiconductor characteristic is provided. As the element, there are, for example, a thin film transistor (hereinafter referred to as a TFT), an MOS transistor, and a diode.

[0004]

[Prior Art]

Recently, a technique for constructing a thin film transistor (TFT) using a semiconductor thin film (about several to several hundreds of nm in thickness) formed on a substrate having an insulating surface for has been noted. The thin film transistor is widely applied to an electronic device such as an IC or the electrooptical device. In particular, a development of the thin film transistor as a switching element of a liquid crystal display device is hastened.

[0005]

In the liquid crystal display device, in order to obtain a high quality image, an active matrix liquid crystal display device in which pixel electrodes are arranged in matrix and the thin film transistor is used as a switching element connected with the respective pixel electrodes has the attention.

[0006]

In addition, in a display performance of the active matrix liquid crystal display device, it is desired that a pixel has a large retaining capacitance and a high aperture ratio. When each pixel has the high aperture ratio, light utilization efficiency is improved and low power consumption and miniaturization of a display device can be achieved.

[0007]

Recently, as a pixel size is minute, a high resolution image is desired. When the

pixel size is minute, formation areas of the TFT and a wiring, which are occupied in one pixel is expanded, and thus the pixel aperture ratio is decreased.

[0008]

Therefore, in order to obtain the high aperture ratio in the respective pixels within a specified pixel size, it is necessary to make the layout of circuit elements required for a circuit structure of the pixel with high efficiency.

[0009]

In addition, in reliability of the active matrix liquid crystal display device, even when it is used for a long period, it is desired that constant display be made without changing an orientation of liquid crystal.

[0010]

Further, after a drive power source is turned off, the liquid crystal is required to return a normal orientation.

[0011]

In addition, it is required that the aperture ratio of the liquid crystal display device is high to display brightly.

[0012]

[Technical Problems before the Present Invention]

As described above, in order to realize a reflection liquid crystal display device and a transmission liquid crystal display device having a high pixel aperture ratio with a small number of masks, a new pixel structure which is not conventionally is required. The present invention improves, in such a liquid crystal display device, a display characteristic and a reliability.

[0013]

A phenomenon which is a problem for the present invention will be described depending on the fact of an experiment below.

[0014]

First, in order to realize the liquid crystal display device having a high pixel aperture ratio with a small number of masks, a pixel structure shown in top views of Figs. 16 and 17 is manufactured. A cross section cut along a dashed line A-A' in the top view of Fig. 16 is shown in Fig. 9. Cross sections cut along dashed lines C-C' in the top views of Figs. 16 and 17 are shown in Fig. 2.

[0015]

In the structures shown in Figs. 16 and 17, a first electrode 485 intersects a first semiconductor film 484 through a gate insulating film and has a function as a gate electrode. In addition, the first electrode and a second semiconductor film 493 are used as capacitor electrodes and the gate insulating film is used as dielectric film, and thus a retaining capacitor 550 is formed. That is, the first electrode has double functions as the gate electrode and the capacitor electrode. A gate wiring 481 is connected with the first electrode 485 through contact hole.

[0016]

In addition, a second electrode 492 is connected with the second semiconductor film 493 through a contact hole. The second electrode 492 has a region in which is in contact with a pixel electrode 491. Through the second electrode 492, the second semiconductor film 493 has the same potential as the pixel electrode 491.

[0017]

The structures shown in Figs. 16 and 17 are characterized in that a TFT element, that is, the gate wiring 481, a source wiring 483, the pixel electrode 491 and the retaining

capacitor 505 are formed using three photo masks. In addition, since the pixel electrode 491 can be overlapped on the source wiring 483 through an insulating film (472 and 473), an aperture ratio can be increased. In Fig. 16, with respect to a pixel in a VGA with 43 μm x 126 μm, an aperture ratio of 54 % is achieved.

[0018]

Figs. 20 to 21 show results of orientations in the pixel portion of the liquid crystal display device, which are observed before a drive power source of a transmission liquid crystal display device having the pixel portion shown in Figs. 16 and 17 is turned on, while a video voltage having ±1 V is applied, and after the drive power source is turned off. Fig. 20 shows microscope photographs of the liquid crystal orientation. Fig. 21 shows the liquid crystal orientation near the gate wiring 481. The same elements as Fig. 17 are referred to as the same numerals in Fig. 21.

[0019]

As the liquid crystal in the transmission liquid crystal display device, positive type liquid crystal ZLI4792 produced by Merck Co., Ltd. is used. An orientation film SE7792 produced by Nissan Chemical Industries, Ltd. is used. The orientation of the liquid crystal is a TN mode. When the orientation is observed, the liquid crystal display device is located such that reflection light and transmission light are simultaneously incident into an optical microscope. An optical system of the microscope is adjusted such that a polarization plate is made with crossed Nicols arrangement with respect to both the transmission light and the reflection light. In order to easily observe a change in the orientation of the liquid crystal, a light shielding film is not intendedly provided in a counter substrate.

[0020]

Here, a signal which is applied by the gate wiring is shown in Fig. 3 when the liquid

crystal display device is driving. In one of the gate wiring of the liquid crystal display device, a pulse of +8V is applied only the period that the gate wiring is chosen. The pulse of -8V is applied only the period that the gate wiring is not chosen. As for the liquid crystal display device which is designed in a specification of VGA, the pulse voltage of +8V is applied during 34.6 μsec that the gate wiring is chosen in which one frame is 16.6 msec. The voltage of -8V is always applied during 16.66 msec in which the gate wiring is not chosen. In one gate wiring, it is understood that the period when the voltage of a negative polarity is applied is overwhelmingly long. In addition, it is understood that a voltage which is equal to or more than a threshold value of the liquid crystal is always applied.

[0021]

With a state before the drive power source is turned on (Figs. 20(A) and 21(A)), a specific phenomenon was not observed in the orientation of the liquid crystal over the first electrode 485.

[0022]

Here, each wiring or potential of the electrode when a video voltage having ±1 V is applied by a gate inverse drive. The gate wiring 481 and the first electrode 485 have a potential of +8 V or –8 V. A source wiring 483, a connection electrode 480, a drain wiring 482, a pixel electrode 491 and a second electrode 492 have a potential of +1 V or –1 V. The liquid crystal is responded by a difference of these potential and the potential of a counter electrode.

[0023]

The orientation in the case where the video voltage having ±1 V is applied by a gate inverse drive is shown in Figs. 20(B) and 21(B). Since a value of the video voltage is equal to or smaller than a threshold value of the liquid crystal, the liquid crystal over the pixel

electrode 491 is not switched. Since a gate voltage having +8 V or –8 V is applied to the liquid crystals over the gate wiring 481 and the first electrode 485, the liquid crystal responds to an electric field and thus oriented such that a major axis of the liquid crystal is in a direction perpendicular to the surface of the substrate. Since the liquid crystal responds to the electric field and perpendicularly oriented, there is a darkly visible region 601 under the polarization plate with the crossed Nicols.

[0024]

The orientation of the liquid crystal after the drive power source is turned off is shown in Figs. 20(C) and 21(C). The orientation of the liquid crystal over the first electrode 485 was fixed and left. In particular, in several tests, even when the drive power source is turned off, there was a tendency that the orientation of the liquid crystal over the retaining capacitor is fixed and left. This region is indicated by reference numeral 602. After the drive power source is turned off, a time until the liquid crystal orientation region 602 is relaxed with the same state as the liquid crystal orientation over the pixel electrode 491 is 10 minutes to 15 minuets.

[0025]

With respect to a reflection liquid crystal display device, display is performed using external light, and even if the power source of the liquid crystal display device is turned off, display light is incident into eyes. Thus, when the region where the orientation is fixed is not shielded, the variations of light and shade by the relaxation process of the liquid crystal are naturally recognized by user's eyes. That is, after the drive power source is turned off, there is a possibility that the variation of brightness is gradually occurred with passing the time and it is a problem.

[0026]

Next, the reliability of the liquid crystal is tested at a high temperature of 85 °C. As for the display pattern, a stripe pattern of black and white longitudinal is alternately repeated. The stripe pattern of black and white is two in a screen respectively. As for a level of black, the video voltage is +5V or -5V and the polarity of the video voltage is changed and applied every adjacent gate line by the gate line inverse drive. As for the level of white, it is always 0V.

[0027]

Here, results by the reliability test of the liquid crystal are shown. Photographs with respect to the orientation at a room temperature after a lapse of 100 hours in the reliability test are shown in Figs. 18 and 19. Fig. 18 shows the orientation photographs. Fig. 19 shows the orientation of the liquid crystal in the pixel portion. The same elements as Fig. 17 are referred to as the same numerals in Fig. 19. As for the observation of the orientation, the region where the voltage having ±5V is applied to the pixel electrode in the reliability test is performed. The observation is performed at a room temperature.

[0028]

Even when the drive power source is tuned off after a lapse of 100 hours in the reliability test, the orientation of the liquid crystal over the first electrode 485 was fixed (Figs. 18(A) and 19(A)). A region in that the orientation of the liquid crystal is fixed is indicated by reference numeral 603. That is, the above mentioned phenomenon that the orientation of the liquid crystal is left after the drive power source is turned off is appeared.

[0029]

Also, the orientation in the case where the video voltage having ±1 V is applied by a gate inverse drive is shown in Figs. 18(B) and 19(B). Since the value of the video voltage is equal to or less than the threshold, the liquid crystals over the connection electrode 480, the

pixel electrode 491, the second electrode 492 and the drain electrode 482 do not respond to an electric field. Since a gate voltage having –8 V is applied to the gate wiring 481 and the first electrode 485, the liquid crystals over these respond to an electric field and thus oriented such that a major axis of the liquid crystal is in a direction perpendicular to the surface of the substrate. Since the liquid crystal responds to the electric field and perpendicularly oriented, there is a darkly visible region 604 under the polarization plate with the crossed Nicols.

[0030]

Next, the orientation of the liquid crystal after the drive power source is turned off is shown in Figs. 18(C) and 19(C). A portion of the orientation of the liquid crystal, which is produced over the first electrode 485 is fixed. A region in that the orientation of the liquid crystal is left after the drive power source is turned off is indicated by reference numeral 605.

[0031]

As for the orientation of the liquid crystal after the drive power source is turned off, the orientation of the liquid crystal which is formed by the electric field at the driving (that is, the orientation of the liquid crystal shown in Figs. 18(B) and 19(B)) is somewhat left.

[0032]

After the drive power source is turned off, a time until the orientation of the liquid crystal over the first electrode 485 is relaxed with its original state became longer with the progression of the reliability test. After the reliability rest for 1000 hours, a time until the liquid crystal over the entire display screen is uniformly oriented is longer than 1 hour. Even when 1000 hours elapses in the reliability test, an occurrence position of the region in that the orientation of the liquid crystal is fixed is not changed and thus was over the first electrode. Over the gate wiring, the region where the orientation of the liquid crystal is fixed is not particularly appeared.

[0033]

Thus, in the reliability test at a high temperature, there was a tendency that a relaxation time of the liquid crystal after the drive power source is turned off becomes longer. If there is such a result, in particular, in the projection type liquid crystal display device, there is a fear that an orientation relaxation time of the liquid crystal after the drive power source is turned off becomes longer. In addition, in the case that the liquid crystal display device is used inside of car, like a car navigation, since a characteristic of the display is changed with time by being exposed high temperature as inside of the car being filled with heat by solar heat, there is a fear that the orientation relaxation time of the liquid crystal after the drive power source is turned off becomes gradually longer.

[0034]

In addition, with respect to the transmission liquid crystal display device, the orientation relaxation process of the liquid crystal can be shielded by cutting a back light. However, with respect to a reflection liquid crystal display device, display is performed using external light, and even if the power source of the liquid crystal display device is turned off, display light is incident into eyes. Thus, if it will be a long time before the orientation of the liquid crystal is relaxed, the variations of light and shade by the relaxation process of the liquid crystal are naturally recognized by user's eyes. In many reflection liquid crystal display devices, a light shielding film is not provided in the counter substrate to increase its intensity. Therefore, the relaxation process of the orientation after the drive power source is turned off is easily recognized relatively to the transmission liquid crystal display device.

[0035]

In addition, also with respect to the transmission liquid crystal display device, because of slipping the light shielding film off, the variations of light by the relaxation process of the

liquid crystal are naturally recognized

[0036]

As a matter of course, the light shielding film can be arranged to hide such an unstable orientation. However, in the case that the liquid crystal display device is used for a long time, the fear that such the region where the orientation is fixed enters inside of the pixel is concerned, an area of the light shielding film must be widely. That is, there is the fear that the aperture ratio is decreased by the light shielding film. It is a problem that such the unstable factor is removed from the liquid crystal display device as possible

[0037]

[Means for solving the Problem]

Methods for solving the above problems inherent in the conventional technique will be described below in details.

[0038]

According to the present invention, after the drive power source is turned off, the electric field that is produced by the charges left in the first electrode is blocked by the second electrode. Thus, the phenomenon is reduced that the orientation of the liquid crystal is changed by the electric field that is produced by the charges left in the first electrode and then fixed and left.

[0039]

According to the present invention, an element structure is devised such that the orientation of the liquid crystal is not fixed and left after the drive power source is turned off. Top views of a pixel portion of the present invention are shown in Figs. 4 and 5. Cross sectional views showing a characteristic of the present invention in the pixel portion are shown in Fig. 1. The same elements as Figs. 16 and 17 are referred to as the same numerals

in Figs. 1, 4, and 5. Fig. 1 shows a cross-section cut along the dashed lines B-B' in the top views of Figs. 4 and 5.

[0040]

The present invention is characterized in that the second electrode 492 is overlapped over the first electrode 485 as shown in Fig. 4. The first electrode 485 is overlapped at 70 % of its area with the second electrode 492, thus, it was found that the orientation of the liquid crystal, which is fixed and left after the drive power source is turned off decreased to a range that there is practically no problem.

[0041]

Particularly, the tendency is seen that the orientation of the liquid crystal which is over a retaining capacitor 505 is fixed and left even if the drive power source is turned off, thus the area of the retaining capacitor 505 is overlapped equal to or more than 90 % with the second electrode 492. Herewith, it is found that the orientation of the liquid crystal, which is fixed and left after the drive power source is turned off, decreased to a range that there is practically no problem. That is, an upper portion of the region where the second semiconductor film 493 which functions as the electrode of the retaining capacitor and the first electrode 485 which functions as the electrode of the retaining capacitor are overlapped, is covered with the second electrode 492.

[0042]

First, the orientation of the liquid crystal after the drive power source is turned off in the case where the present invention is applied will be described. The orientation of the liquid crystal in the pixel portion before the transmission liquid crystal display device of the present invention is driven, the orientation of the liquid crystal while the video voltage having ±1 V is applied, and the orientation of the liquid crystal after the drive power source is turned

off are shown in Figs. 12 and 13.

[0043]

Figs. 12(A) and 13(A) show the orientation of the liquid crystal, which is viewed through the microscope, before the drive power source is turned on. The liquid crystal is made with uniform twisted orientation over the entire pixel portion.

[0044]

Figs. 12(B) and 13(B) show the orientation of the liquid crystal, which is viewed through the microscope, while the video voltage having ±1 V is applied to the transmission liquid crystal display device. The second electrode 492 is overlapped over the first electrode 485. Thus, the electric filed that is produced by the first electrode 485 is blocked by the second electrode.

[0045]

Since the drain electrode 482 and the second electrode 492 are next to the pixel electrode 491, +1V or -1V is applied to the liquid crystal which is over the second electrode 492. Since a voltage equal to or lower than the threshold value of the liquid crystal is applied, the liquid crystal over the second electrode is not switched

[0046]

Since the voltage having -8 V or +8 V is applied over the gate wiring 481, the liquid crystal corresponds to the electric field. This region is indicated by reference numeral 606.

[0047]

Then, the driver power source is turned off. Figs. 12(C) and 13(C) show the orientation of the liquid crystal after the drive power source is turned off. The orientation of the liquid crystal over the first electrode 485 was returned to normal orientation.

[0048]

A darkly visible portion over a connection electrode 480 in the pixel located in the left side of the photograph of Fig. 12(C) is a column spacer formed patterning a photosensitive material.

[0049]

Next, although not shown, the video voltage having an amplitude of ±5 V is applied and then the liquid crystal over the electrode 491, the connection electrode 480 and the second electrode 492 is oriented in a direction perpendicular to the substrate by the video voltage having an amplitude of ±5 V. Further, the liquid crystal over the gate wiring 481 is oriented in a direction perpendicular to the surface of the substrate by applying the gate voltage having +8 V. The drive power source is turned off, and then the liquid crystal over the first electrode 485 is returned to the normal twisted orientation.

[0050]

In addition, the orientations of the liquid crystal after the reliability test of the liquid crystal display device is performed for 100 hours at a high temperature of 85 °C are shown in Figs. 10 and 11. After it is driven with the set video voltage having ±1 V for several minutes and then the drive power source is turned off, a region in which the orientation of the liquid crystal is fixed was not observed. In other words, as shown in Figs. 11(A) and 11(C), there is particularly no irregularity in the orientation of the liquid crystal over the first electrode 485. In Fig. 11(B), a region in which the liquid crystal is switched by a voltage on the gate wiring at driving is indicated by reference numeral 606. Although not shown, even when the drive power source is turned off after the video voltage having amplitude of ±5 V is applied, the orientation of the liquid crystal was quickly returned to a normal state.

[0051]

When the orientation of the liquid crystal over the first electrode 485 after the drive

power source is turned off in Fig. 10(C) is compared with that in Fig. 18(C) and Fig. 19(C), the utility of the present invention can be easily understood. In other words, according to the present invention, the region in which the orientation of the liquid crystal over the first electrode 485 is fixed, as viewed in Fig. 18(C) and Fig. 19(C), is not almost observed. Thus, the orientation of the liquid crystal was quickly returned to a normal state even when the drive power source is turned off.

[0052]

In Figs. 18(C) and 19(C), the first electrode 485 is overlapped at 70 % of its area with the second electrode 492. Herewith, the region in that the orientation of the liquid crystal is fixed and left after the drive power source is turned off was decreased to a range that there is practically no problem. Of course, as the area of the second electrode 492 that overlaps the first electrode 485 is expanded, the region in that the orientation of the liquid crystal is fixed and left becomes narrower.

[0053]

Simultaneously, in Figs. 18(C) and 19(C), the retaining capacitor 505 is overlapped at 90 % of its area with the second electrode 492. Herewith, the region in that the orientation of the liquid crystal is fixed and left after the drive power source is turned off was decreased to a range that there is practically no problem. Of course, as the area of the second electrode 492 that overlaps the retaining capacitor 505 is expanded, the region in that the orientation of the liquid crystal is fixed and left becomes narrower.

[0054]

A principle of the above phenomenon will be described using Figs. 1and 2.

[0055]

Fig. 2 is a view for comparison to the present invention. Cross sectional views of the

element structures are obtained by cutting the top views of Figs. 16 and 17 along the dashed lines C-C'.

[0056]

In Fig. 2, a counter substrate of the liquid crystal display device is composed of a substrate 701 and a counter electrode 702 which is formed by patterning a transparent electrode formed on the substrate 701. Orientation films 703 are formed in the counter substrate and the active matrix substrate. Rubbing directions 705 and 706 of the orientation films are optionally set, however conveniently they are orthogonal to each other. The liquid crystal 704 is injected between the substrates. The liquid crystal is made with twisted orientation at a twisted angle of 90°.

[0057]

The orientation of the liquid crystal while the liquid crystal display device is driven with the set video voltage having ±5 V by gate line inversion is shown in Figs. 2(A). A voltage having –5 V is applied among a drain electrode 482, the pixel electrode 491 and the counter electrode 702. The liquid crystal molecule over the drain electrode 482 and the pixel electrode 491 is switched and oriented in a direction perpendicular to the surface of the substrate. A voltage of –8 V is applied to the gate wiring 481. The liquid crystal molecule over the gate wiring is oriented in a direction perpendicular to the surface of the substrate. Although a voltage loss is slightly caused by a first interlayer insulating film 472 and a second interlayer insulating film 473, a voltage equal to or larger than the threshold voltage of the liquid crystal is applied to the liquid crystal over the first electrode 485. Thus, the liquid crystal responds to the electric field. A voltage of +5 V as the potential of the pixel electrode that is in contact with the second electrode 492 is applied to the liquid crystal over the second electrode 492.

[0058]

The orientation of the liquid crystal after the drive power source is turned off is shown in Fig. 2(B). Charges are left in the first electrode 485 and the electric field in a longitudinal direction is produced between it and the counter electrode 702. Further, the electric field in a lateral direction is produced between the first electrode 485 and the second electrode 492 or the gate wiring 481. A liquid crystal molecule 707 is oriented by the electric field that is produced between the plurality of electrodes and the first electrode 485. In other words, the orientation of the liquid crystal molecule 707 over the first electrode 485 is fixed and then left.

[0059]

The liquid crystal molecule 707 over the pixel electrode 491, the drain electrode, and the gate wiring 481 is returned to the normal orientation.

[0060]

A reason for that the orientation of the liquid crystal is fixed and left as shown in Fig. 2(B) after the drive power source is turned off was considered as follows. Since a thickness of the insulating film (the first insulating film 472 and the second insulating film 473) over the first electrode 485 is 2 μm and thin when the charge is left over the first electrode after the drive power source is turned off, the electric field by the charge which is left over the first electrode is too large to ignore and the voltage is pressured partially to the liquid crystal molecule.

[0061]

Since the first electrode 485 and the gate wiring 481 are connected with each other through the contact hole, a contact resistance is high and charges in the first electrode are hard to discharge from a structural factor.

[0062]

Particularly, the phenomenon that the orientation of the liquid crystal is fixed is seen over the retaining capacitor 505, however it is concerned that a charge that the first electrode 485 and the second semiconductor film 493 is stored as a capacitor electrode of a retaining capacitor is hard to discharge even after the drive power source is turned off.

[0063]

The cross sections showing a characteristic of the present invention in the pixel portion are shown in Fig. 1. The cross sectional views of Fig. 1 are obtained by manufacturing the transmission liquid crystal display device using the active matrix substrate having the pixel portion of Figs. 4 and 5. The cross sections obtained by cutting the active matrix substrate of Figs. 4 and 5 along the dashed lines B-B' is shown.

[00064]

In Fig. 1, a counter substrate of the liquid crystal display device is composed of a substrate 701 and a counter electrode 702 which can be formed by patterning a transparent electrode formed on the substrate 701. Orientation films 703 are formed in the counter substrate and the active matrix substrate. Rubbing directions 705 and 706 of the orientation films are orthogonal to each other. The liquid crystal 704 is injected between the substrates.

[0065]

The orientation of the liquid crystal while the liquid crystal display device is driven with the set video voltage having ±5 V by gate line inversion is shown in Fig. 1(A). The drain electrode 482 and the pixel electrode 491 have a potential of –5 V. The second electrode 492 that is in contact with the pixel electrode of an adjacent pixel has a potential of +5 V. The gate wiring 481 has a potential of -8 V. A voltage sufficient to orient liquid crystal molecule 707 in a direction perpendicular to the surface of the substrate is applied.

[0066]

The orientation of the liquid crystal after the drive power source is turned off is shown in Fig. 1(B). Even if charges are left in the first electrode 485, an electric field by the charges is blocked by the second electrode 492. Thus, the orientation of the liquid crystal over the first electrode 485 becomes twisted orientation indicated in the case of a voltage of 0 V.

[0067]

When the comparison with respect to the orientation of the liquid crystal molecule is made in Figs. 1(B) and 2(B), an effect of the present invention is easily understood. According to the structure of Fig. 1(B), to which the present invention is applied, there is the following effect. That is, the electric filed that is produced by the charges left in the first electrode 485 after the drive power source is turned off is blocked by the second electrode 492, and thus the leakage of the electric field into a liquid crystal layer is prevented. Therefore, after the drive power source is turned off, the orientation of the liquid crystal is not fixed and left, and thus returned to the normal orientation.

[0068]

In the present invention, since the response of the liquid crystal by the electric field which is made by the charge which is remained in the first electrode under the insulating film cannot be ignored and further the gate wiring and the first electrode is connected through a contact hole and a contact resistance is big, so a charge is easy to remain in the first electrode, the charge which is remained in the first electrode by the second electrode is blocked. In addition, since the charge which is stored in the retaining capacitor is not discharged and easy to be left, the second electrode is overlapped over the retaining capacitor.

[0069]

According to the present invention, such an unstable factor that the orientation is fixed

to be left can be decreased even in a long-term reliability test.

[0070]

In addition, in the structures shown in Figs. 1, 4 and 5, the first electrode 485 has functions as the gate electrode and a capacitor electrode. However, as for the first electrode of the present invention, it is not limited and can be widely applied to the electrode having the voltage of the same electric potential as the gate electrode.

[0071]

In addition, in the structures shown in Figs. 1, 4 and 5, the second electrode has functions as the second semiconductor film 493 and a pixel electrode 491. However, as for the second electrode of the present invention, it is not limited. The electrode which is formed over the insulating film in the first electrode and formed over the first electrode, and has a function that the electric field by the charge which is remained in the first electrode is blocked from a liquid crystal layer after the drive power source is turned off may be the second electrode.

[0072]

In addition, in the structures shown in Figs. 1, 4 and 5, the insulating film is a lamination film of a first interlayer insulating film 472 and a second interlayer insulating film 473. However, as for the insulating film of the present invention, it is not limited. A single layer film and the insulating film that more than two layers are laminated may be the insulating film of the present invention.

[0073]

The present invention can be applied to an electrooptical device that is represented by a liquid crystal display device. In addition, the present invention can be widely applied to a semiconductor device for performing display by applying the electric field.

[0074]

[Embodiment Modes of the Invention]

An embodiment mode of the present invention will be described below using Figs. 1 and 5. Fig. 5 shows a top view of a pixel portion of an active matrix substrate. Fig. 1 shows cross sections obtained by cutting the top view of the pixel portion of Fig. 5 along a dashed line B-B'.

[0075]

The active matrix substrate includes a gate wiring 481 arranged in a row direction, a source wiring 483 arranged in a column direction, a pixel portion having a pixel TFT near the intersection of the gate wiring and the source wiring, and a driver circuit having an n-channel TFT and a p-channel TFT. Note that the gate wiring indicates the gate wiring 481 electrically connected with the gate electrode 485.

[0076]

As shown in Fig. 5, in the pixel portion, a first semiconductor film 484 and a second semiconductor film 493 are formed. The first semiconductor film 484 functions as the active layer of a TFT element in practice. The second semiconductor film 493 functions as a capacitor electrode of a retaining capacitor 505 as described later.

[0077]

After a gate insulating film (not shown) is formed, a first electrode 485 and the source wiring 483 are formed so as to be in contact with the gate insulating film.

[0078]

As the insulating film, a first interlayer insulating film and a second interlayer insulating film (both not shown) are formed. As the first interlayer insulating film, an inorganic film such as silicon oxide or silicon oxynitride is used. A film thickness of the

first interlayer insulating film is set to be 10 nm to 400 nm. As the second interlayer insulating film, an organic resin film such as an acrylic resin film, a polyimide resin film, or a benzocyclobutene (BCB) film is used. A film thickness of the second interlayer insulating film is set to be 0.8 μm to 1.6μm. A total film thickness of the first interlayer insulating film and the second interlayer insulating film is equal to or thinner than 2.0μm. Relative dielectric constants of the first interlayer insulating film and the second interlayer insulating film are 3.0 to 4.0.

[0079]

Next, the first interlayer insulating film and the second interlayer insulating film are patterned to form contact holes 801 to 805.

[0080]

Next, after a conductor film is formed, the gate wiring 481, a connection electrode 480, the second electrode 492, and the drain electrode 482 are formed by patterning.

[0081]

By the contact holes 801 and 802, the first semiconductor film 484 and the source wiring 483 are electrically connected with each other.

[0082]

By the contact hole 803, the first semiconductor film 484 and the drain wiring 482 are electrically connected with each other.

[0083]

By the contact hole 804, the second semiconductor film 493 and the second electrode 492 are electrically connected with each other.

[0084]

By the contact hole 805, the first electrode 485 and the gate wiring 481 are electrically

connected with each other.

[0085]

Next, a transparent electrode is patterned and thus a pixel electrode 491 is formed to overlap the drain electrode 482 and the second electrode 492.

[0086]

With respect to the retaining capacitor, the second semiconductor film 493 and the first electrode 485, which are provided in each pixel are used as electrodes. The gate insulating film (not shown) functions as a dielectric film of the retaining capacitor. The second semiconductor film 493 has the same potential as the pixel electrode 491. The first electrode 485 has the same potential as the gate wiring.

[0087]

Here, the first electrode 485 is overlapped at 70% or more of its area with second electrode 480 to block the electric field that is produced by the charge which is left after the driver power source is turned off. Alternatively, instead of the second electrode, the first electrode 485 may be overlapped at 70 % or more of its area with the pixel electrode 491 or the pixel electrode and the second electrode. In other wards, the first electrode may be overlapped at 70% or more of its area with a dielectric film

[0088]

In addition, on an insulating film that the first interlayer insulating film and the second interlayer insulating film are laminated, the retaining capacitor may be overlapped at 90 % or more of its area with the second electrode 492.

[0089]

The structure of the above mentioned pixel portion can be manufactured by five pieces of masks. As mentioned below in the embodiment 1, a driver circuit TFT and a pixel TFT

can be formed on one substrate by using polysilicon for the semiconductor film of TFT element. At this time, an n-channel TFT and an p-channel TFT are required to manufacture a CMOS circuit. Depending on a manufacturing process of the element, one more additional mask is necessary as the mask doping impurity element to provide p-type. Even so, the number of necessary masks is sufficiently six to form the element substrate having the pixel portion shown in fig. 5

[0090]

That is, the first is the mask to pattern the first semiconductor film 484 and the second semiconductor film 493, the second is the mask to pattern the first electrode 485 and the source wiring 483, the third is the mask to form contact holes 801 to 804 to the first interlayer insulating film 484 and the second interlayer insulating film, the fourth is the mask to pattern the gate wiring 481, the drain electrode 482, the second electrode 492 and the connection electrode 480, the fifth is the mask to pattern the pixel electrode 491. Moreover, a mask is used to dope p-type impurity.

[0091]

In this embodiment, the transmission liquid crystal display device is shown. However, when the drain electrode is formed using aluminum, silver, or the like, which has a high reflectance and thus has a function as the pixel electrode, a reflection liquid crystal display device can be manufactured.

[0092]

As in this embodiment, when a film thickness of the insulating film as a laminate layer of the first interlayer insulating film and the second interlayer insulating film is equal to or thinner than 2.0μm, an effect that the electric field that is produced by the left charges is applied to the liquid crystal cannot be ignored. Thus, even after the driver power source is

turned off, the orientation of the liquid crystal is easy to fix and leave.

[0093]

When the liquid crystal layer and the insulating film are electrically, connected in series, as a capacitance of the insulating film is higher, the voltage is easy to be applied to the liquid crystal layer. Since a capacitance per an unit area of the insulating film in which the first interlayer insulating film and the second interlayer insulating film are laminated, is big, equal to or more than 0.018 [mF/m^2], an effect that the electric field that is produced by the left charges is applied to the liquid crystal cannot be ignored, so the voltage is also pressured partially to the liquid crystal molecule and then after the driver power source is turned off, the orientation of the liquid crystal is easy to be fixed and left.

[0094]

In addition, since the first electrode 485 and the gate wiring 481 are connected through the contact hole, a contact resistance is high and charges in the first electrode are hard to discharge from a structural factor and easy to leave in the first electrode.

[0095]

In such a structure, the first electrode 485 is overlapped at 70 % of its area with the second electrode 492, and then such an unstable factor that the orientation of the liquid crystal is fixed to be left over the first electrode 485 after the drive power source is turned off can be decreased and the liquid crystal display device can be a level which is practically no problem.

[0096]

In addition, in such a structure, the retaining capacitor 505 is overlapped at 90 % of its area with the second electrode 492, and then such an unstable factor that the orientation of the liquid crystal is fixed to be left over the first electrode 485 after the drive power source is turned off can be decreased and the liquid crystal display device can be a level which is

practically no problem.

[0097]

This is because the electric field produced by the charges left in the electrode after the driver power source is turned off is blocked by the conductor film and thus the leakage of the electric field into the liquid crystal layer can be prevented.

[0098]

In the present invention made with the above structure, the following embodiment will be described in details.

[0099]

[Embodiment]

[Embodiment 1]

Figs. 7 to 9 are used to explain Embodiments of the present invention. In this embodiment, a manufacturing method is explained precisely according to steps which is forming pixel TFT of the pixel portion and the storage capacitor; driver circuit TFT provided in periphery portion of the display region simultaneously.

[0100]

In this embodiment, a description is set forth regarding a step for fabricating the pixel TFTs, which is switching elements in the pixel portion and TFTs for driver circuit (a signal line driver circuit and a scanning line driver circuit, or the like) provided in peripheral of the pixel portion over a same substrate. For the simplicity of the explanation, a CMOS circuit which is a fundamental structure circuit for the driver circuit portion, and an n-channel TFT for a pixel TFT in a pixel portion are illustrated with the cross section taken along a path.

[0101]

First, as shown in Fig. 7(A), a base film 401 made of an insulating film such as a

silicon oxide film, a silicon nitride film, or a silicon oxynitride film, is formed on a substrate 400 made of a glass such as barium borosilicate glass or aluminum borosilicate glass, typically a glass such as Corning Corp. #7059 glass or #1737 glass. For example, a lamination film of a silicon oxynitride film 401a, manufactured from SiH_4, NH_3, and N_2O by plasma CVD, and formed having a thickness of 10 to 200 nm (preferably between 50 and 100 nm), and a hydrogenated silicon oxynitride film 401b, similarly manufactured from SiH_4 and N_2O, and formed having a thickness of 50 to 200 nm (preferably between 100 and 150 nm), is formed. A two layer structure is shown for the base film 401 in the present embodiment, but a single layer film of the insulating film, and a structure in which more than two layers are laminated, may also be formed.

[0102]

Island shape semiconductor films 402 to 406 are formed by crystalline semiconductor films made from a semiconductor film having an amorphous structure, using a laser crystallization method or a known thermal crystallization method. The thickness of the island shape semiconductor films 402 to 406 may be formed from 25 to 80 nm (preferably between 30 and 60 nm). There are no limitations placed on the materials for forming a crystalline semiconductor film, but it is preferable to form the crystalline semiconductor films by silicon or a silicon germanium (SiGe) alloy.

[0103]

A laser such as a pulse oscillation type or continuous light emission type excimer laser, a YAG laser, or a YVO_4 laser can be used to fabricate the crystalline semiconductor films by the laser crystallization method. A method of condensing laser light emitted from a laser oscillator into a linear shape by an optical system and then irradiating the light to the semiconductor film may be used when these types of lasers are used. The crystallization

conditions may be suitably selected by the operator, but when using the excimer laser, the pulse oscillation frequency is set to 30 Hz, and the laser energy density is set form 100 to 400 mJ/cm^2 (typically between 200 and 300 mJ/cm^2). Further, when using the YAG laser, the second harmonic is used and the pulse oscillation frequency is set from 1 to 10 kHz, and the laser energy density may be set from 300 to 600 mJ/cm^2 (typically between 350 and 500 mJ/cm^2). The laser light condensed into a linear shape with a width of 100 to 1000 μm, for example 400 μm, is then irradiated over the entire surface of the substrate. This is performed with an overlap ratio of 80 to 98% for the linear laser light.

[0104]

A gate insulating film 407 is formed covering the island shape semiconductor films 402 to 406. The gate insulating film 407 is formed of an insulating film containing silicon with a thickness of 40 to 150 nm by plasma CVD or sputtering. A 120 nm thick silicon oxynitride film is formed in the present embodiment. The gate insulating film is not limited to this type of silicon oxynitride film, of course, and other insulating films containing silicon may also be used in a single layer or in a lamination structure. For example, when using a silicon oxide film, it can be formed by plasma CVD with a mixture of TEOS (tetraethyl orthosilicate) and O_2, at a reaction pressure of 40 Pa, with the substrate temperature set from 300 to 400℃, and by discharging at a high frequency (13.56 MHz) electric power density of 0.5 to 0.8 W/cm^2. Good characteristics as a gate insulating film can be obtained by subsequently performing thermal annealing, at between 400 and 500℃, of the silicon oxide film thus manufactured.

[0105]

A first conductive film 408 and a second conductive film 409 are then formed on the gate insulating film 407 in order to form gate electrodes. The first conductive film 408 is

formed of a TaN film with a thickness of 50 to 100 nm, and the second conductive film 409 is formed of a W film having a thickness of 100 to 300 nm, in the present embodiment.

[0106]

The W film is formed by sputtering with a W target, which can also be formed by thermal CVD using tungsten hexafluoride (WF_6). Whichever is used, it is necessary to make the film become low resistance in order to use it as the gate electrode, and it is preferable that the resistivity of the W film be made equal to or less than 20 μOcm. The resistivity can be lowered by enlarging the crystal grains of the W film, but for cases in which there are many impurity elements such as oxygen within the W film, crystallization is inhibited, thereby the film becomes high resistance. A W target having a purity of 99.9999% is thus used in sputtering. In addition, by forming the W film while taking sufficient care that no impurities from the gas phase are introduced at the time of film formation, the resistivity of 9 to 20 μOcm can be achieved.

[0107]

Note that, although the first conductive film 408 is a TaN and the second conductive film 409 is a W in the present embodiment, both may also be formed from an element selected from the group consisting of Ta, W, Ti, Mo, Al, and Cu, or from an alloy material having one of these elements as its main constituent, and a chemical compound material. Further, a semiconductor film, typically a polycrystalline silicon film into which an impurity element such as phosphorus is doped, may also be used. Examples of preferable combinations other than that used in the present embodiment include: forming the first conductive film by tantalum (Ta) and combining it with the second conductive film formed from a W; forming the first conductive film by tantalum nitride (TaN) and combining it with the second conductive film formed from an Al film; and forming the first conductive film by

tantalum nitride (TaN) and combining it with the second conductive film formed from a Cu.

[0108]

Then, masks 410 to 417 are formed from resist, a resist and a first etching treatment is performed in order to form electrodes and wirings. An ICP (inductively coupled plasma) etching method is used in the present embodiment. An etching gas is mixed, and a plasma is generated by applying a 500 W RF electric power (13.56 MHz) to a coil shape electrode at 1 Pa. A 100 W RF electric power (13.56 MHz) is also applied to the substrate side (test piece stage), effectively applying a negative self-bias voltage. Selecting appropriately etching gas, the W film and the TaN film are etched to the approximately same level.

[0109]

Edge portions of the first conductive layer and the second conductive layer are made into a tapered shape in accordance with the effect of the bias voltage applied to the substrate side under the above etching conditions by using a suitable resist mask shape. The angle of the tapered portions is from 15 to 45°. The etching time may be increased by approximately 10 to 20% in order to perform etching without any residue remaining on the gate insulating film. The selectivity of a silicon oxynitride film with respect to a W film is from 2 to 4 (typically 3), and therefore approximately 20 to 50 nm of the exposed surface of the silicon oxynitride film is etched by this over-etching process. First shape conductive layers 419 to 425 (first conductive layers 419a to 425a and second conductive layers 419b to 425b) are thus formed of the first conductive layers and the second conductive layers in accordance with the first etching process. Reference numeral 418 denotes a gate insulating film, and the regions not covered by the first shape conductive layers 419 to 425 are made thinner by etching of about 20 to 50 nm.

[0110]

A first doping process is then performed, and an impurity element which imparts n-type conductivity is added. (Fig. 7(B)) Ion doping or ion injection may be performed for the method of doping. Ion doping is performed under the conditions of a dose amount of from $1x10^{13}$ to $5x10^{14}$ atoms/cm^2 and an acceleration voltage of 60 to 100 keV. A periodic table group 15 element, typically phosphorus (P) or arsenic (As) is used as the impurity element which imparts n-type conductivity, and phosphorus (P) is used here. The conductive layers 419 to 423 become masks with respect to the n-type conductivity imparting impurity element in this case, and first impurity regions 427 to 430 are formed in a self-aligning manner. The impurity element which imparts n-type conductivity is added to the first impurity regions 427 to 430 with a concentration in the range of $1x10^{20}$ to $1x10^{21}$ atoms/cm^3.

[0111]

A second etching process is performed next, as shown in Fig. 7(C). The ICP etching method is similarly used. A plasma is generated by introducing a reaction gas to a chamber and a supplying a predetermined RF electric power (13.56 MHz) to a coil shape electrode. Low RF electric power (13.56 MHz) is applied to the substrate side (test piece stage), and a self-bias voltage which is lower in comparison to that of the first etching process is applied. The W film is etched anisotropically forming second shape conductive layers 494 to 499.

[0112]

A second doping process is then performed, as shown in Fig. 7(C). The dose amount is made smaller than that of the first doping process in this case, and an impurity element which imparts n-type conductivity is doped under high acceleration voltage conditions. For example, doping is performed with the acceleration voltage set from 70 to 120 keV, and a dose amount of $1x10^{13}$ /cm^2, and a new impurity region is formed inside the first impurity

region formed in the island shape semiconductor films of Fig. 7(B). The second conductive layers 494 to 498 are used as masks with respect to the impurity element, and doping is performed so as to also add the impurity element into regions under the first conductive layers 494a to 498a. Second impurity regions 608 to 612 that overlap the first conductive layers 494a to 498a are formed. The impurity element which imparts n-type conductivity is added such that the concentration becomes from $1x10^{17}$ to $1x10^{18}$atoms/cm^3 in the second impurity regions.

[0113]

As shown in Fig. 8(A), the first conductive layer, TaN, is backward and also etched by etching the gate insulating film 432. Third shape conductive layers 433 to 438 (first conductive layers 433a to 438a and second conductive layers 433b to 438b) are formed. Reference numeral 432 denotes a gate insulating film, and the regions not covered by the third shape conductive layers 433 to 438 are made thinner by etching of about 20 to 50 nm.

[0114]

In Fig. 8(A), third impurity region 600 to 603 which is overlapped with the conductive layers 433a to 437a and fourth impurity region 604 to 607 which is outside the third impurity region are formed. Therefore the concentration of an impurity element which imparts n-type conductivity into third impurity region and fourth impurity region is equal to an impurity element in second impurity region approximately.

[0115]

Forth impurity regions 454 to 456 having a conductivity type which is the opposite of the above conductive type impurity element, are then formed as shown in Fig. 8(B) in the island shape semiconductor films 403 which form p-channel TFTs. A third shape conductive layer 434 is used as a mask with respect to the impurity element, and the impurity

regions are formed in a self-aligning manner. The island shape semiconductor films 402, 404, 405, and 406 which form n-channel TFTs, are covered over their entire surface areas by resist masks 451 to 453. Phosphorus is added to the impurity regions 455 to 456 at a different concentration, and ion doping is performed here using diborane (B_2H_6), so that the respective impurity regions have the impurity concentration of 2×10^{20} to 2×10^{21} atoms/cm^3.

[0116]

Impurity regions are formed in the respective island shape semiconductor films by the above processes. The conductive layers 433 to 437 overlapping the island shape semiconductor layer function as gate electrodes of TFT. Further, reference numeral 437 functions as a capacitance wiring, 438 functions as a wiring inside the driver circuit.

[0117]

A process of activating the impurity elements added to the respective island shape semiconductor films is then performed, as shown in Fig. 8(C), with the aim of controlling conductivity type. Thermal annealing using an annealing furnace is performed for this process. In addition, laser annealing and rapid thermal annealing (RTA) can also be applied. Thermal annealing is performed with an oxygen concentration equal to or less than 1 ppm, preferably equal to or less than 0.1 ppm, in a nitrogen atmosphere at 400 to 700℃, typically between 500 and 600℃. Heat treatment is performed for 4 hours at 500℃ in the present embodiment. However, for cases in which the wiring material used in the wirings 433 to 438 is weak with respect to heat, it is preferable to perform activation after forming an interlayer insulating film (having silicon as its main constituent) in order to protect the wirings and the like.

[0118]

In addition, heat treatment is performed for 1 to 12 hours at 300 to 450℃ in an

atmosphere containing between 3 to 100% hydrogen, performing hydrogenation of the island shape semiconductor films. This process is one of terminating dangling bonds in the island shape semiconductor films by hydrogen which is thermally excited. Plasma hydrogenation (using hydrogen excited by a plasma) may also be performed as another means of hydrogenation.

[0119]

A first interlayer insulating film 472 is formed of a silicon oxynitride film having a thickness of 100 to 200 nm as Fig. 9. An acrylic resin film or a polyimide resin film is formed to 1.8μm thick as a second interlayer insulating film 473 made of an organic insulating material on the first interlayer insulating film 472. Etching is then performed in order to form contact holes.

[0120]

Next, a conductive metal film is formed by a sputtering method or a vacuum evaporation method. That is, first, a Ti film is formed to have a thickness of 50 to 150 nm. A contact is formed between the Ti film and a semiconductor film composing a source or a drain region of an island shape semiconductor film. Aluminum (Al) is formed to have a thickness of 300 to 400 nm on the Ti film, and then a Ti film or a titanium nitride (TiN) film is formed to have a thickness of 100 to 200 nm. Thus, a three layered structure is obtained.

[0121]

Then, in the driver circuit portion, source wirings 474 to 476 for contact with the source regions of the island shape semiconductor films and drain wirings 477 to 479 for contact with the drain regions thereof are formed.

[0122]

In addition, in the pixel portion, the connection electrode 480, the gate wiring 481, the

drain electrode 482, and the second electrode 492 are formed. In the present embodiment, the first electrode 485 is overlapped at 70 % of its area with the second electrode.

[0123]

The connection electrode 480 is electrically connected with the source wiring 483 and the first semiconductor film 484. Although not shown, the gate wiring 481 is electrically connected with the first electrode 485 through the contact hole. The drain electrode 482 is electrically connected with the drain region of the first semiconductor film 484. The second electrode 492 is electrically connected with the second semiconductor film 493, and thus the second semiconductor film 493 functions as the electrode of the retaining capacitor 505.

[0124]

After that, a transparent conductive film is formed on the entire surface and the pixel electrode 491 is formed by patterning and etching using a photo mask. The pixel electrode 491 is formed on the second interlayer insulating film 473 and a portion overlapped with the drain electrode 482 of the pixel TFT and the second electrode 492 is provided in the pixel electrode 491. Thus, a connection structure is formed.

[0125]

As a material of the transparent conductive film, indium oxide (In_2O_3), an alloy of indium oxide and tin oxide (In_2O_3–SnO_2;ITO), or the like can be used. The transparent conductive film is formed using the above material by a sputtering method, a vacuum evaporation method, or the like. Such a material is etched using a chlorine system solution. However, in particular, etching of the ITO is easy to cause the residue. Thus, in order to improve processing by etching, an alloy of indium oxide and zinc oxide (In_2O_3–ZnO) may be used. The alloy of indium oxide and zinc oxide has superior surface smoothness and thermal stability superior to the ITO. Thus, corrosion reaction to Al in contact with edges of the

drain electrode 482 can be prevented. Similarly, zinc oxide (ZnO) is a suitable material and in order to further improve transmittance of visual light and conductivity, zinc oxide (ZnO:Ga) to which gallium (Ga) is added, or the like can be used.

[0126]

Thus, the active matrix substrate corresponding to the transmission liquid crystal display device can be completed.

[0127]

By the above processes, the driver circuit portion having an n-channel TFT 501, a P-channel TFT 502, and an n-channel TFT 503 and the pixel portion having a pixel TFT 504 and the retaining capacitor 505 can be formed on the same substrate. In this specification, such a substrate is called an active matrix substrate for convenience.

[0128]

The n-channel TFT 501 in the driver circuit portion has a channel forming region 468, third impurity regions 441 (GOLD regions) overlapped with a conductive layer 433 composing the gate electrode, fourth impurity regions 446 (LDD regions) formed outside the gate electrode, and first impurity regions 427 which function as the source region or the drain region. The p-channel TFT 502 has a channel forming region 469, fifth impurity regions 456 overlapped with a conductive layer 434 composing the gate electrode, and sixth impurity regions 455 which function as the source region or the drain region. The n-channel TFT 503 has a channel forming region 470, third impurity regions 443 (GOLD regions) overlapped with a conductive layer 435 composing the gate electrode, fourth impurity regions 448 (LDD regions) formed outside the gate electrode, and first impurity regions 429 which function as the source region or the drain region.

[0129]

The pixel TFT 504 in the pixel portion has a channel forming region 471, third impurity regions 444 (GOLD region) overlapped with the a conductive layer 436 composing the gate electrode, fourth impurity regions 449 (LDD region) formed outside the gate electrode, and first impurity regions 430 which functions as the source region or the drain region. In addition, an impurity element for providing a n-type is added to the semiconductor film 430 which functions as one electrode of the retaining capacitor 505. The retaining capacitor is constructed by a capacitance wiring 437, and an insulating layer located therebetween (the same layer as the gate insulating film).

[0130]

Cross sections obtained by cutting along dashed lines A-A' and D-D' in Fig. 9 correspond to those obtained by cutting the top view of Fig. 5 along dashed lines A-A' and D-D'.

[0131]

When the active matrix substrate of this embodiment is the transmission liquid crystal display device according to the method of Embodiment 3, because of a high contact resistance by connecting the first electrode and the gate wiring through the contact hole, the charges are easy to be left over the first electrode after the drive power source is turned off. In addition, since the first interlayer insulating film and the second interlayer insulating film are thin and then the capacitance is big, even after the drive power source is turned off, the liquid crystal which is connected in series is applied the voltage considerably by the charge which is left in the electrode. However, the first electrode 485 is overlapped at 70 % of its area with the second electrode, and then the electric field produced by the charges left in the electrode can be blocked.

[0132]

The first electrode 485 is overlapped at 70 % of its area as a wide area with the second electrode. Thus, an unstable factor that the orientation is fixed to be left after the drive power source is turned off can be decreased.

[0133]

[Embodiment 2]

The method of manufacturing the active matrix substrate in Embodiment 1 can be applied to the reflection liquid crystal display device.

[0134]

First, processes are progressed in accordance with Figs. 7 to 8 in Embodiment 1 to obtain the structure of Fig. 8(C).

[0135]

Then, as shown in Fig. 15, a first interlayer insulating film 472 is formed using a silicon oxynitride film to have a thickness of 100 to 200 nm and an acrylic resin film or a polyimide film is formed thereon to have a thickness of 1.8 μm as a second interlayer insulating film 473 made of an organic insulator material. Next, an etching process for forming contact holes is performed.

[0136]

Next, a conductive metal film is formed by a sputtering method or a vacuum evaporation method. That is, first, a Ti film is formed to have a thickness of 50 to 150 nm. A contact is formed between the Ti film and a semiconductor film composing a source region or a drain region of an island shape semiconductor film. Aluminum (Al) is formed to have a thickness of 300 to 400 nm on the Ti film, and then a Ti film or a titanium nitride (TiN) film is formed to have a thickness of 100 to 200 nm. Thus, a three layered structure is obtained.

[0137]

Then, in the driver circuit portion, source wirings 474 to 476 for contact with the source regions of the island shape semiconductor films and drain wirings 477 to 479 for contact with the drain regions thereof are formed.

[0138]

In addition, in the pixel portion, the connection electrode 480, the gate wiring 481, and the drain electrode 482 are formed. In this embodiment, the drain electrode 482 has a function as the pixel electrode in the reflection liquid crystal display device. The first electrode 485 is overlapped at 70 % of its area with the drain electrode 482.

[0139]

With respect to the retaining capacitor, the second semiconductor film 493 and the first electrode 485, which are provided in each pixel are used as electrodes. The gate insulating film (not shown) functions as a dielectric film of the retaining capacitor. The second semiconductor film 493 has the same potential as the pixel electrode 491. The first electrode 485 has the same potential as the gate wiring.

[0140]

The connection electrode 480 is electrically connected with the source wiring 483 and the first semiconductor film 484. Although not shown, the gate wiring 481 is electrically connected with the first electrode 485 through the contact hole. The drain electrode 482 is electrically connected with the drain region of the first semiconductor film 484. In addition, the drain electrode 482 is electrically connected with the second semiconductor film 493, and thus the second semiconductor film 493 functions as the electrode of the retaining capacitor 505.

[0141]

Thus, the active matrix substrate corresponding to the reflection liquid crystal display

device can be completed.

[0142]

By the above processes, the driver circuit portion having an n-channel TFT 501, a P-channel TFT 502, and an n-channel TFT 503 and the pixel portion having a pixel TFT 504 and the retaining capacitor 505 can be formed on the same substrate. In this specification, such a substrate is called an active matrix substrate for convenience.

[0143]

The n-channel TFT 501 in the driver circuit portion has a channel forming region 468, third impurity regions 441 (GOLD regions) overlapped with a conductive layer 433 composing the gate electrode, fourth impurity regions 446 (LDD regions) formed outside the gate electrode, and first impurity regions 427 which function as the source region or the drain region. The p-channel TFT 502 has a channel forming region 469, fifth impurity regions 456 overlapped with a conductive layer 434 composing the gate electrode, and sixth impurity regions 455 which function as the source region or the drain region. The n-channel TFT 503 has a channel forming region 470, third impurity regions 443 (GOLD regions) overlapped with a conductive layer 435 composing the gate electrode, fourth impurity regions 448 (LDD regions) formed outside the gate electrode, and first impurity regions 429 which function as the source region or the drain region.

[0144]

The pixel TFT 504 in the pixel portion has a channel forming region 471, third impurity regions 444 (GOLD regions) overlapped with a conductive layer 436 composing the gate electrode, fourth impurity regions 449 (LDD regions) formed outside the gate electrode, and first impurity regions 430 which function as the source region or the drain region. In addition, an impurity element for providing a n-type is added to the semiconductor film 430

which functions as one electrode of the retaining capacitor 505. The retaining capacitor is constructed by the semiconductor film 493, the first electrode 505, and the retaining capacitor is constructed by a capacitance wiring 437, and an insulating layer located therebetween (the same layer as the gate insulating film).

[0145]

Cross sections obtained by cutting the top view of Fig. 14 along dashed lines E-E' and F-F' correspond to those taken along dashed lines E-E' and F-F' in Fig. 15.

[0146]

When the active matrix substrate of this embodiment can be the reflection liquid crystal display device according to the method of Embodiment 3. As for the active matrix substrate of this embodiment, since the first electrode and the gate wiring are connected through the contact hole, the charges are easy to be left over the first electrode after the drive power source is turned off. In addition, since the thickness of the insulating film which is formed between the first electrode and the pixel electrode is thin, the electric field produced by the charges left in the first electrode applies considerably to the liquid crystal layer. However, the first electrode 485 is overlapped at 70 % of its area with the second electrode, and then the electric field produced by the charges left in the electrode can be blocked and thus the leakage of the electric field into the liquid crystal layer can be prevented.

[0147]

[Embodiment 3]

In this embodiment, the manufacturing process of an active matrix liquid crystal display device from the active matrix substrate manufactured in Embodiment 1 is described below. Fig. 6 is used for explanation.

[0148]

First, in accordance with Embodiment 1, the active matrix substrate in a state shown in Fig. 9 is obtained, and thereafter, an alignment film 512 is formed on the active matrix substrate of Fig. 9, and is subjected to a rubbing process. Note that, in this embodiment, before the formation of the alignment film 512, a columnar spacer for maintaining a gap between the substrates is formed at a desired position by patterning an organic resin film such as an acrylic resin film. Further, spherical spacers may be scattered on the entire surface of the substrate in place of the columnar spacer.

[0149]

Next, an opposing substrate 508 is prepared. On the opposing substrate 508, there are formed a colored layers, a light shielding layer and color filters arranged to correspond to the respective pixels. Further, the driver circuit portion is also provided with a light shielding layer. A leveling film is provided to cover the color filters and the light shielding layer. Next, in the pixel portion an opposing electrode 510 is formed from a transparent conductive film on the leveling film, an alignment film 511 is formed on the entire surface of the opposing substrate, and a rubbing process is conducted thereon.

[0150]

Then, the active matrix substrate on which a pixel portion and a driver circuit are formed is stuck with the opposing substrate by a sealing agent 513. A filler is mixed in the sealing agent 513, and the two substrates are stuck with each other while keeping a uniform gap by this filler and the columnar spacer. Thereafter, a liquid crystal material 514 is injected between both the substrates to encapsulate the substrates completely by an encapsulant (not shown). A known liquid crystal material may be used as the liquid crystal material 514. Thus, the active matrix liquid crystal display device shown in Fig. 6 is completed. Then, if necessary, the active matrix substrate and the opposing substrate are

parted into desired shapes. In addition, by using a known technique, a polarizing plate or the like may be suitably provided. Then, an FPC is stuck with the substrate using a known technique.

[0151]

The liquid crystal display panel obtained in this way can be used as a display portion of various electronic devices.

[0152]

[Embodiment 4]

The TFTs formed by implementing an embodiment among above-mentioned Embodiments 1 to 3 can be applied to all of the electronic equipments having these electro-optical devices as the display section.

[0153]

The following can be given as examples of the electronic equipment: video cameras; digital cameras; projectors; head mounted displays (goggle type display); car navigation systems; car stereo; personal computers; portable information terminals (such as mobile computers, portable telephones and electronic notebook). An example of these is shown in Figs. 22, 23 and 24.

[0154]

Fig. 22(A) shows a personal computer, and it includes a main body 2001, an image input section 2002, a display portion 2003, and a keyboard 2004. The present invention is applicable to the display portion 2003.

[0155]

Fig. 22(B) shows a video camera, and it includes a main body 2101, a display portion 2102, a voice input section 2103, operation switches 2104, a battery 2105, and an image receiving section 2106. The present invention is applicable to the display portion 2102.

[0156]

Fig. 22(C) shows a mobile computer, and it includes a main body 2201, a camera section 2202, an image receiving section 2203, operation switches 2204, and a display portion 2205. The present invention is applicable to the display portion 2205.

[0157]

Fig. 22(D) shows a goggle type display, and it includes a main body 2301; a display portion 2302; and an arm section 2303. The present invention is applicable to the display portion 2302.

[0158]

Fig. 22(E) shows a player using a recording medium which records a program (hereinafter referred to as a recording medium), and it includes a main body 2401; a display portion 2402; a speaker section 2403; a recording medium 2404; and operation switches 2405. This player uses DVD (Digital Versatile Disc), CD, etc. for the recording medium, and can be used for music appreciation, film appreciation, games and Internet. The present invention is applicable to the display portion 2402.

[0159]

Fig. 22(F) shows a digital camera, and it includes a main body 2501; a display portion 2502; a view finder 2503; operation switches 2504; and an image receiving section (not shown in the figure). The present invention can be applied to the display portion 2502.

[0160]

Fig. 23(A) is a front-type projector, and it includes a projection device 2601 and a screen 2602. The present invention is applicable to a liquid crystal display device 2808 which comprises one of the projection device 2601, and other driver circuit.

[0161]

Fig. 23(B) is a rear-type projector, and it includes a main body 2701, a projection device 2702, a mirror 2703, and a screen 2704. The present invention is applicable to a liquid crystal display device 2808 which comprises one of the projection device 2702, and other driver circuit.

[0162]

Fig. 23(C) is a diagram showing an example of the structure of the projection devices 2601, 2702 in Figs. 23A and 23B. The projection device 2601 or 2702 comprises a light source optical system 2801, mirrors 2802, 2804 to 2806, dichroic mirrors 2803, a prism 2807, liquid crystal display devices 2808, phase difference plates 2809, and a projection optical system 2810. The projection optical system 2810 is composed of an optical system including a projection lens. This example shows an example of three plate type but not particularly limited thereto. For instance, the invention may be applied also to a single plate type optical system. Further, in the light path indicated by an arrow in Fig. 23(C), an optical system such as an optical lens, a film having a polarization function, a film for adjusting a phase difference, and an IR film may be suitably provided by a person who carries out the invention.

[0163]

Fig. 23(D) is a diagram showing an example of the structure of the light source optical system 2801 in Fig. 23(C). In this embodiment, the light source optical system 2801 comprises a reflector 2811, a light source 2812, lens arrays 2813, 2814, a polarization conversion element 2815, and a condenser lens 2816. The light source optical system shown in Fig. 23(D) is merely an example, and is not particularly limited to the illustrated structure. For example, a person who carries out the invention is allowed to suitably add to the light source optical system an optical system such as an optical lens, a film having a polarization function, a film for adjusting a phase difference, and an IR film.

[0164]

Note that a transmission electro-optical device is used as the projector shown in Fig. 23, a reflection type electro-optical device is not illustrated.

[0165]

Fig. 24(A) is a portable telephone, and it includes a main body 2901, an audio output section 2902, an audio input section 2903, a display portion 2904, operation switches 2905, and an antenna 2906. The present invention can be applied to the display portion 2904.

[0166]

Fig. 24(B) is a portable book (electronic book), and it includes a main body 3001, display portions 3002 and 3003, a recording medium 3004, operation switches 3005, and an antenna 3006. The present invention can be applied to the display portions 3002 and 3003.

[0167]

Fig. 24(C) is a display, and it includes a main body 3101, a support stand 3102, and a display portion 3103. The present invention can be applied to the display portion 3103. The

display of the present invention is advantageous for a large size screen in particular, and is advantageous for a display equal to or greater than 10 inches (especially equal to or greater than 30 inches) in diagonal.

[0168]

The applicable range of the present invention is thus extremely wide, and it is possible to apply the present invention to electronic equipment in all fields. Further, the electronic equipment of the present embodiment can be realized by using a constitution of any combination of the embodiments 1 to 3.

[0169]

[Effect of the Invention]

As described above, according to the present invention, the electric field that is produced by the charges left in the first electrode is blocked by the second electrode. Thus, the phenomenon can be reduced that the orientation of the liquid crystal is changed by the electric field that is produced by the charges left in the electrode and then fixed and left. Therefore, a display device in which a deterioration of the liquid crystal is reduced, the long term reliability is high and the preferable display quality is obtained can be realized.

[Brief Description of the Drawings]

[Fig. 1] Views explaining a principle of the present invention

[Fig. 2] Comparison views explaining a principle of the present invention

[Fig. 3] A view showing a signal which is applied to a gate wiring of a liquid crystal display device

[Fig. 4] A top view of a pixel portion of the present invention

[Fig. 5] A top view of a pixel portion of the present invention

[Fig. 6] A cross sectional view of a liquid crystal display device

[Fig. 7] Cross sectional views showing a process for manufacturing a thin film transistor

[Fig. 8] Cross sectional views showing a process for manufacturing a thin film transistor

[Fig. 9] A cross sectional view showing a process for manufacturing the thin film transistor

[Fig. 10] Photographs showing orientation of liquid crystal after a high temperature reliability test is performed for the liquid crystal display device of the present invention

[Fig. 11] Top views showing the orientation of the liquid crystal after the high temperature reliability test is performed for the liquid crystal display device of the present invention

[Fig. 12] Photographs showing the orientation of the liquid crystal in the liquid crystal display device of the present invention

[Fig. 13] Top views showing the orientation of the liquid crystal in the liquid crystal display device of the present invention

[Fig. 14] A top view of the pixel portion of the present invention

[Fig. 15] A cross sectional view of the pixel portion of the present invention

[Fig. 16] A top view of the pixel portion

[Fig. 17] A top view of the pixel portion

[Fig. 18] Photographs showing the orientation of the liquid crystal after the high temperature reliability test is performed for the liquid crystal display device

[Fig. 19] Top views showing the orientation of the liquid crystal after the high temperature reliability test is performed for the liquid crystal display device

[Fig. 20] Photographs showing the orientation of the liquid crystal in the liquid crystal display device

[Fig. 21] Top views showing the orientation of the liquid crystal in the liquid crystal display device

[Fig. 22] Examples showing an electronic equipment

[Fig. 23] Examples showing an electronic equipment

[Fig. 24] Examples showing an electronic equipment

[Name of Document] Abstract

[Summary]

[Problem] An unstable factor that the orientation of liquid crystal is fixed and left after a drive power source is turned off is reduced.

[Solving Means] When an interlayer insulating film is equal to or thinner than 2.0 μm and a capacitance is big, after a drive power source is turned off, a response of the liquid crystal by the electric field which is made by the charge which is remained in the electrode under the insulating film cannot be ignored. Particularly, a wiring and the electrode is connected through a contact hole and a contact resistance is big, so the charge is easy to remain in the electrode. Therefore, the charge which is remained in the electrode after the drive power source is turned off is blocked by a dielectric film.

[Selected drawing] Fig. 1

【FIG. 1】

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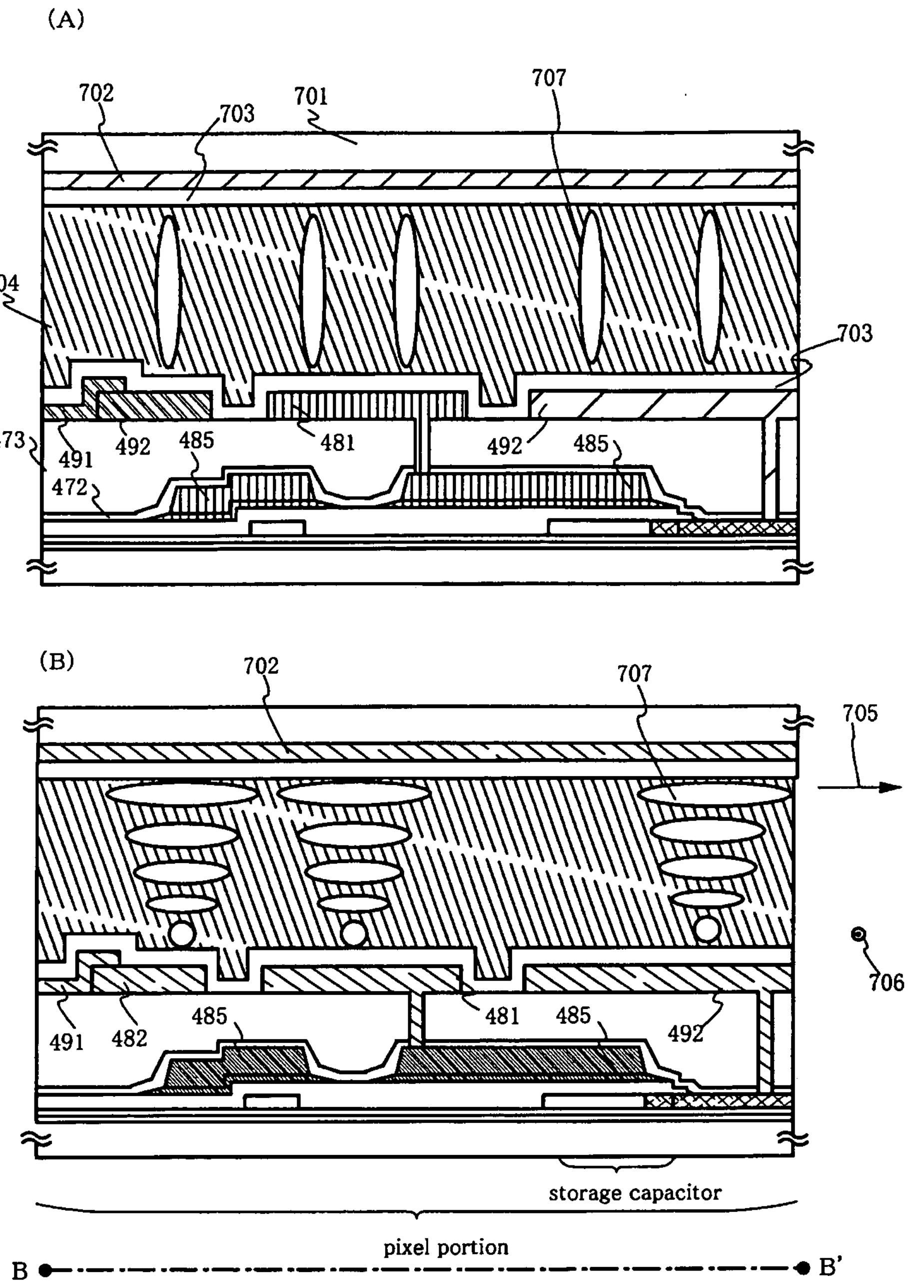
FEB 2 2 2005
PATENT & TRADEMARK OFFICE



(A)

: conductor having electric potential of −5V
: conductor having electric potential of +5V
} same electric potential as pixel electrode

: conductor having electric potential of −8V } same electric potential as gate wiring

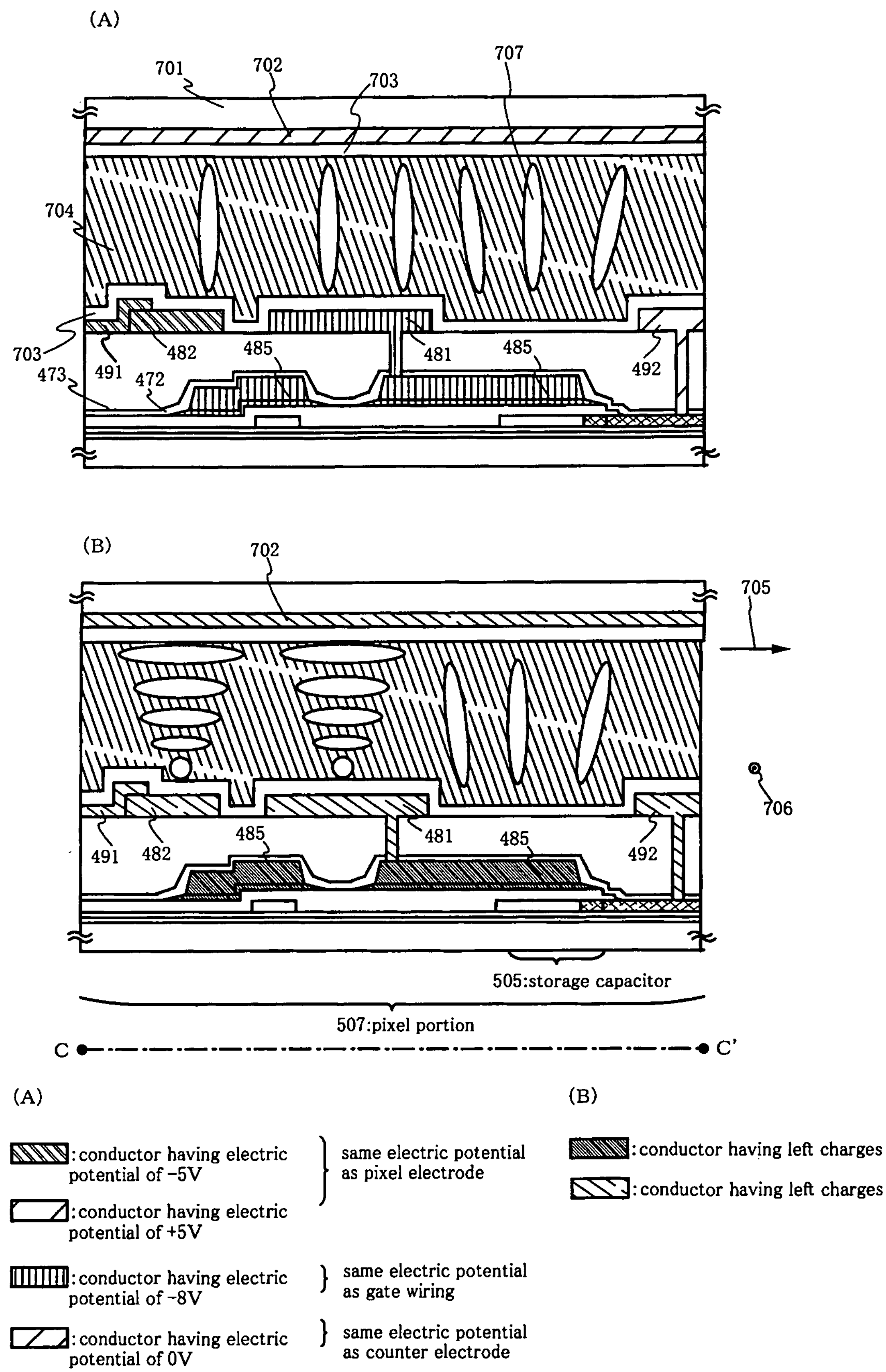
: conductor having electric potential of 0V } same electric potential as counter electrode

(B)

: conductor having left charges

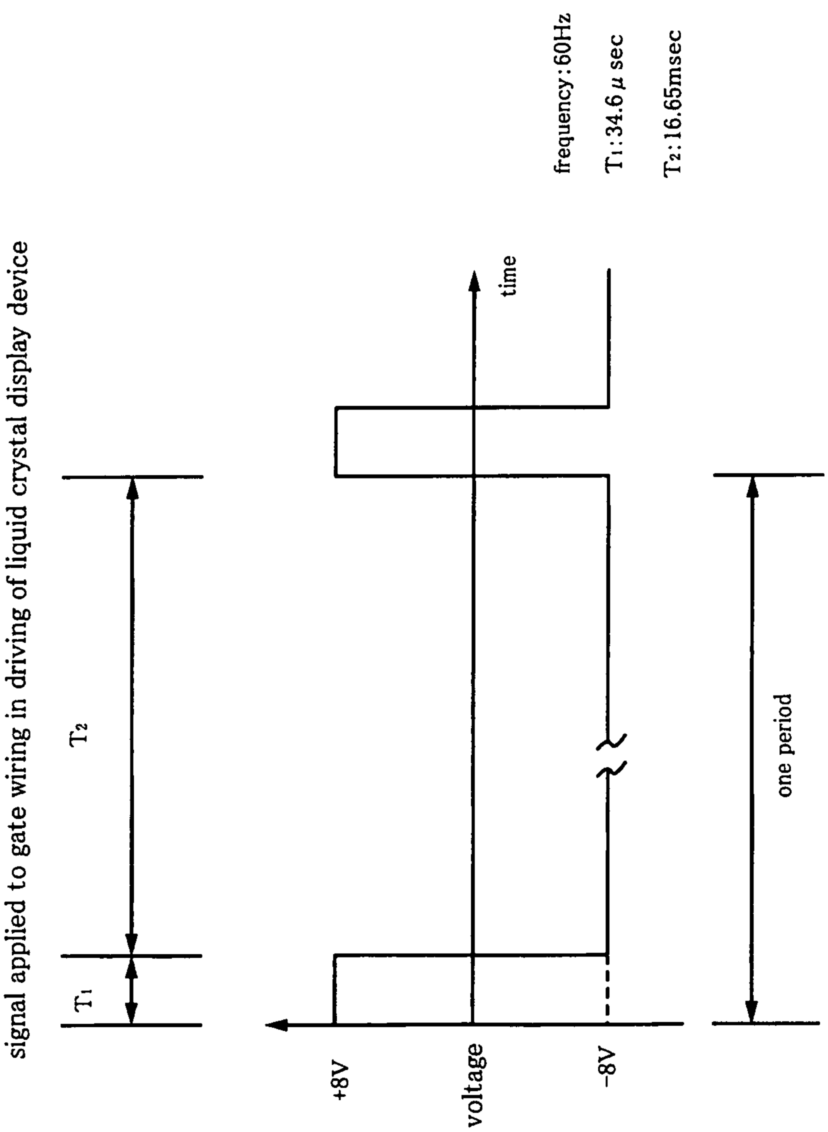
: conductor having left charges

[FIG. 2]



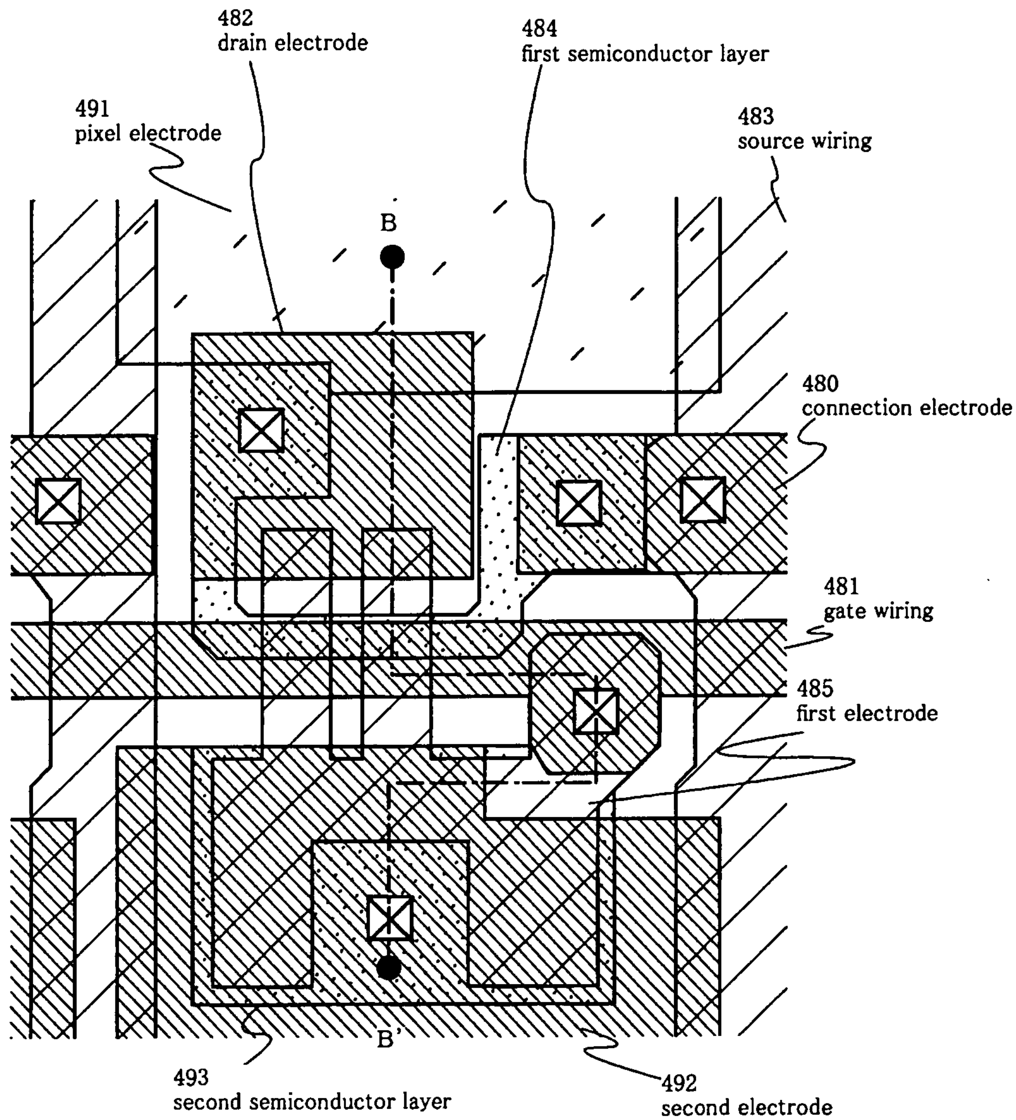
(A)
701
702
703
707
704
703
473
491
472
482
485
481
485
492
(B)
702
705
706
491
482
485
481
485
492
505:storage capacitor
507:pixel portion
C
C'
(A)
: conductor having electric potential of -5V
: conductor having electric potential of +5V
same electric potential as pixel electrode
: conductor having electric potential of -8V
same electric potential as gate wiring
: conductor having electric potential of 0V
same electric potential as counter electrode
(B)
: conductor having left charges
: conductor having left charges

【FIG. 3】



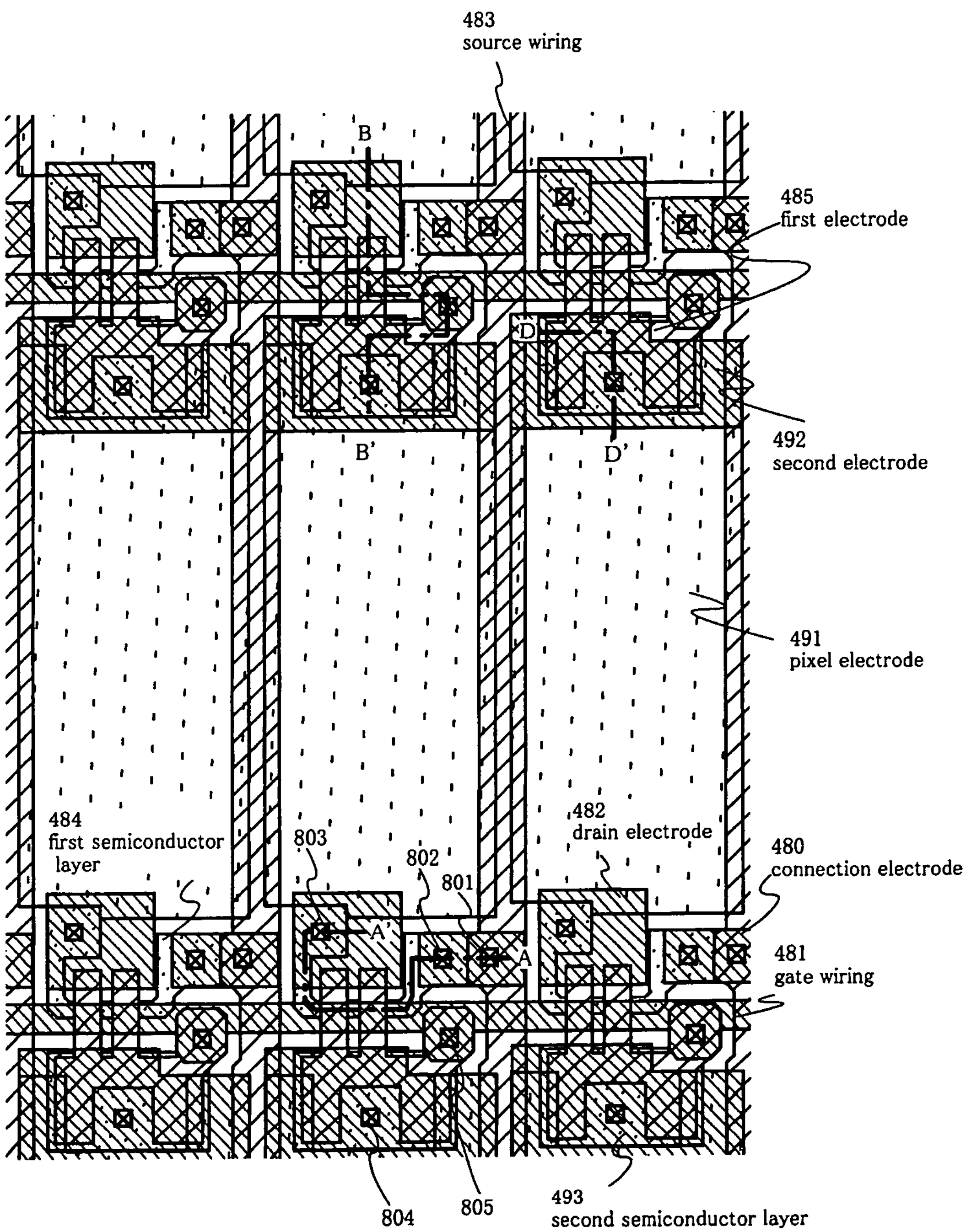
signal applied to gate wiring in driving of liquid crystal display device
frequency: 60Hz
T1: 34.6 μ sec
T2: 16.65msec
T1
T2
time
+8V
voltage
-8V
one period

【FIG. 4】



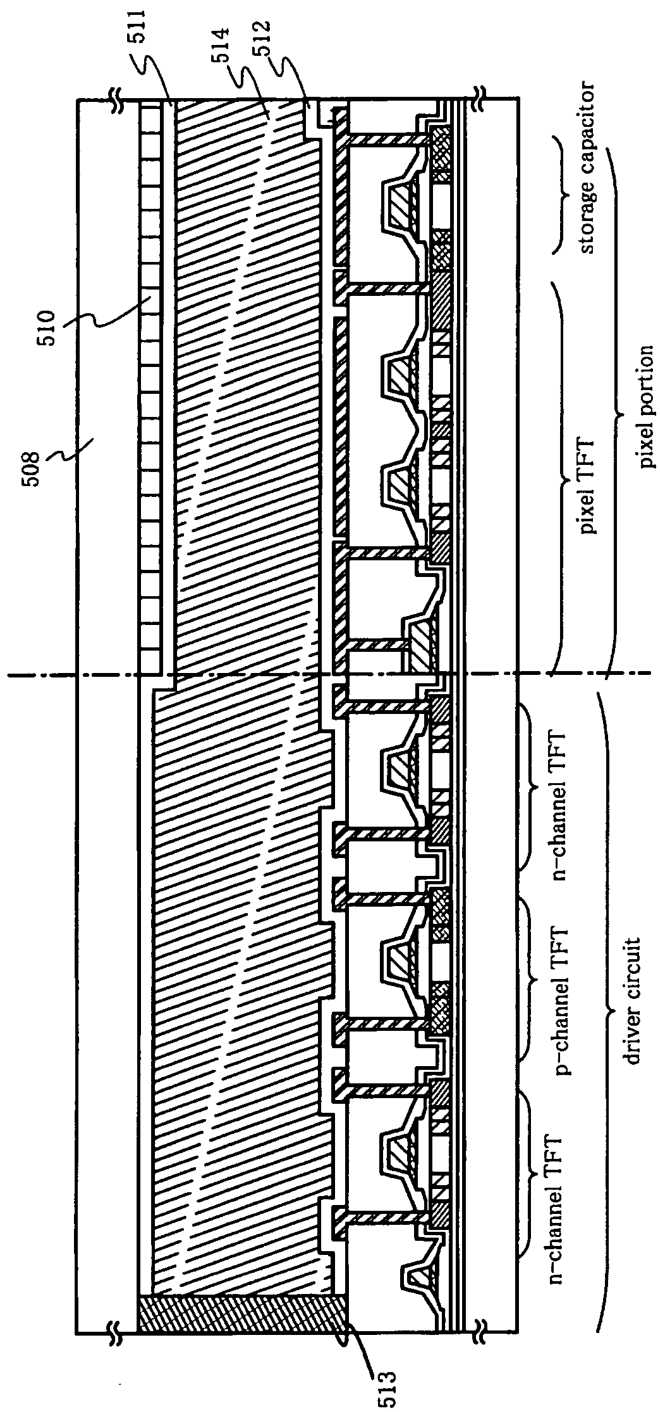
482
drain electrode
484
first semiconductor layer
491
pixel electrode
483
source wiring
B
480
connection electrode
481
gate wiring
485
first electrode
B'
493
second semiconductor layer
492
second electrode

【FIG. 5】



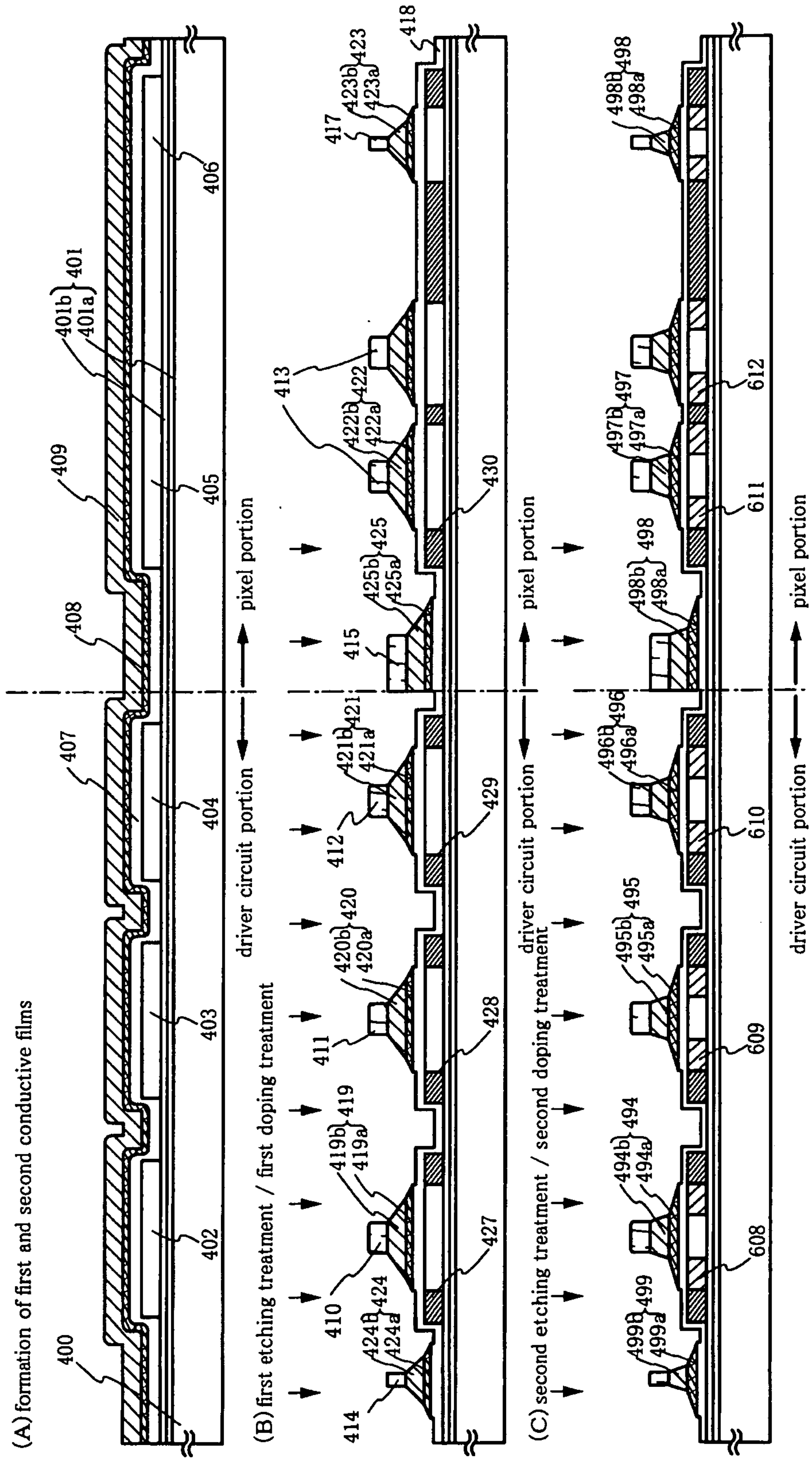
483
source wiring
B
485
first electrode
D
492
second electrode
B'
D'
491
pixel electrode
484
first semiconductor
layer
803
802
801
482
drain electrode
480
connection electrode
A'
A
481
gate wiring
804
805
493
second semiconductor layer

【FIG. 6】

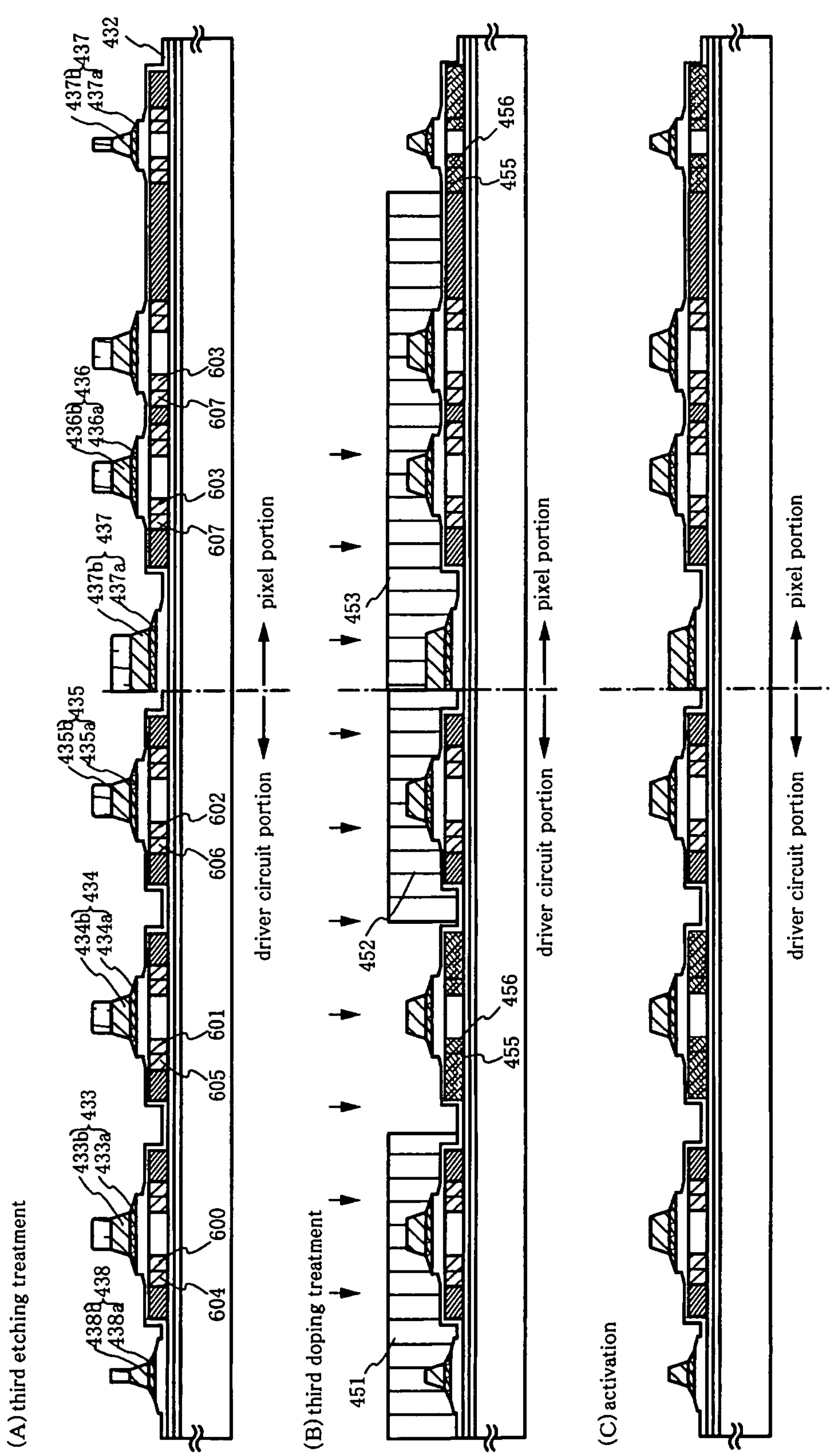


511
514
512
510
508
513
storage capacitor
pixel TFT
pixel portion
n-channel TFT
p-channel TFT
n-channel TFT
driver circuit

【FIG. 7】

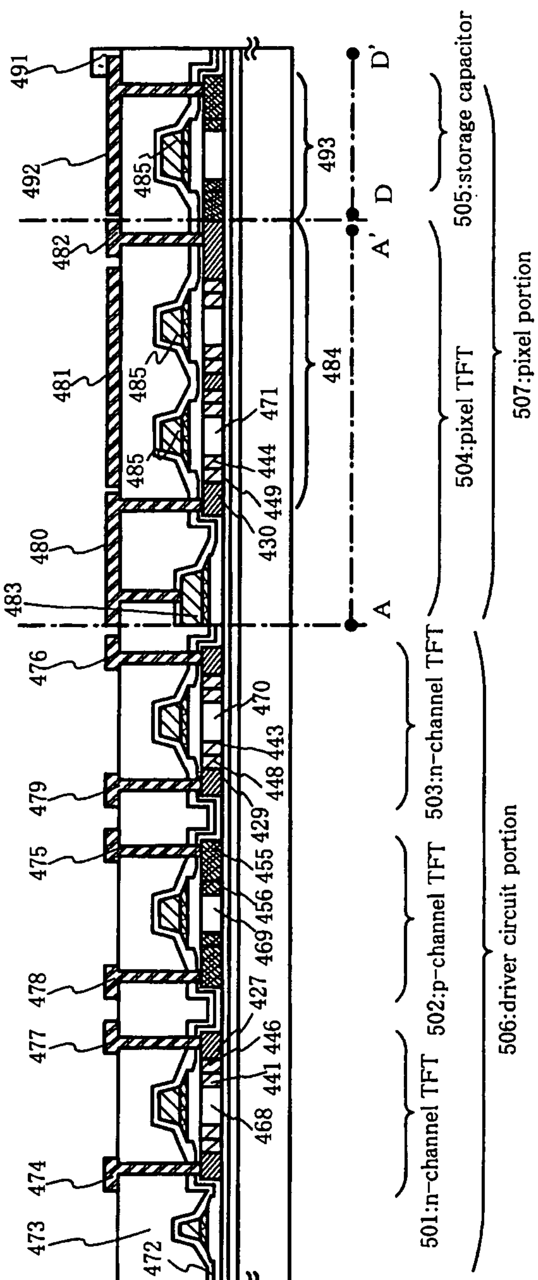

(A) formation of first and second conductive films
(B) first etching treatment / first doping treatment
(C) second etching treatment / second doping treatment
driver circuit portion
pixel portion
400
401
401a
401b
402
403
404
405
406
407
408
409
410
411
412
413
414
415
417
418
419
419a
419b
420
420a
420b
421
421a
421b
422
422a
422b
423
423a
423b
424
424a
424b
425
425a
425b
427
428
429
430
494
494a
494b
495
495a
495b
496
496a
496b
497
497a
497b
498
498a
498b
499
499a
499b
608
609
610
611
612

【FIG. 8】



(A) third etching treatment
438b
438a
438
433b
433a
433
434b
434a
434
435b
435a
435
437b
437a
437
436b
436a
436
437b
437a
437
432
604
600
605
601
606
602
607
603
607
603
driver circuit portion
pixel portion
(B) third doping treatment
451
452
453
455
456
455
456
(C) activation

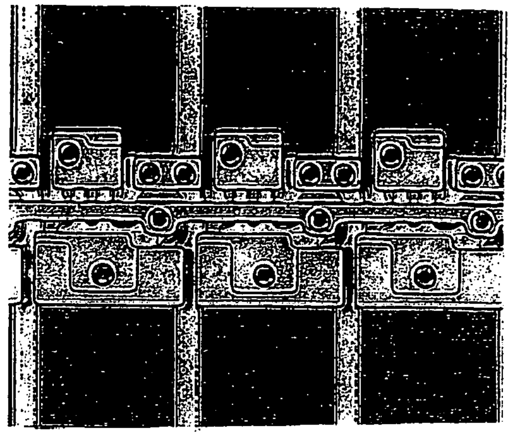
【FIG. 9】



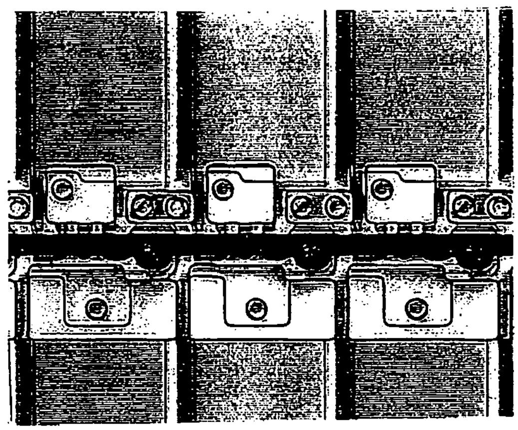
491
492
482
481
480
483
476
479
475
478
477
474
473
472
485
471
444
449
430
470
443
448
429
455
456
469
427
446
441
468
493
484
A
A'
D
D'
501:n-channel TFT
502:p-channel TFT
503:n-channel TFT
504:pixel TFT
505:storage capacitor
506:driver circuit portion
507:pixel portion

【FIG. 10】

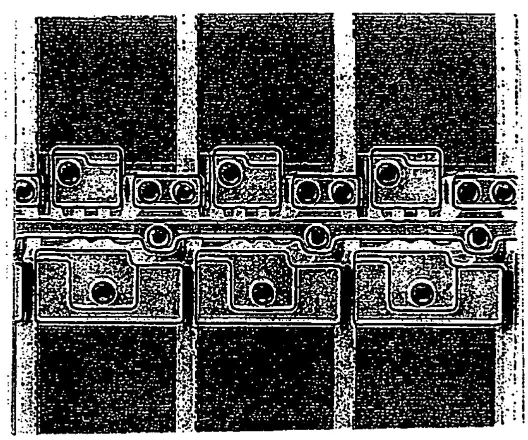
(A)
soon after drive power source is turned off after 100 hours driving



(B)
case wherein video voltage of ±1V is applied



(C)
after drive power source is turned off



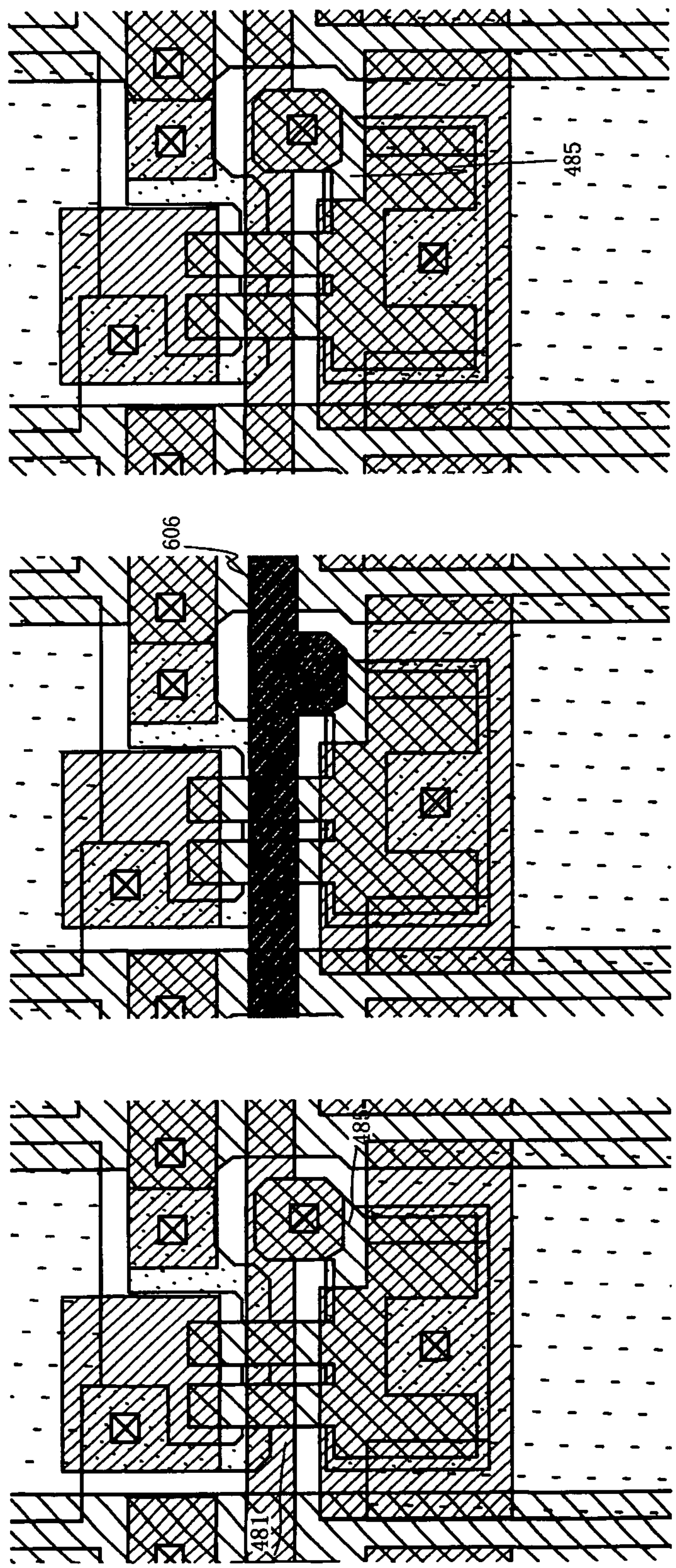
orientation of liquid crystal after reliability test of 100 hours
(85℃ ±5V after driving, liquid crystal ZLI4792)

【FIG. 11】

(A) soon after drive power source is turned off after 100 hours driving

(B) case wherein video voltage of ±1V is applied

(C) after drive power source is turned off



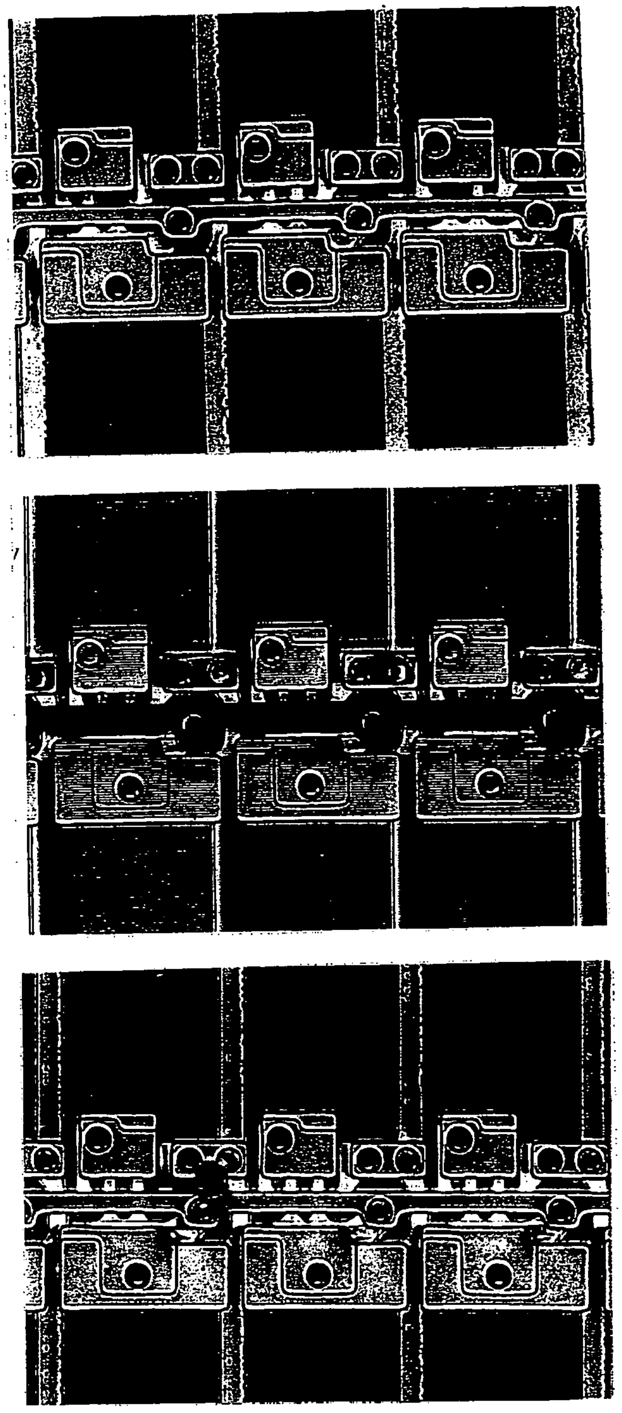
orientation of liquid crystal after reliability test of 100 hours
(85℃ ±5V after driving, liquid crystal ZLI4792)

【FIG.12】

(A)
before drive power
source is turned on

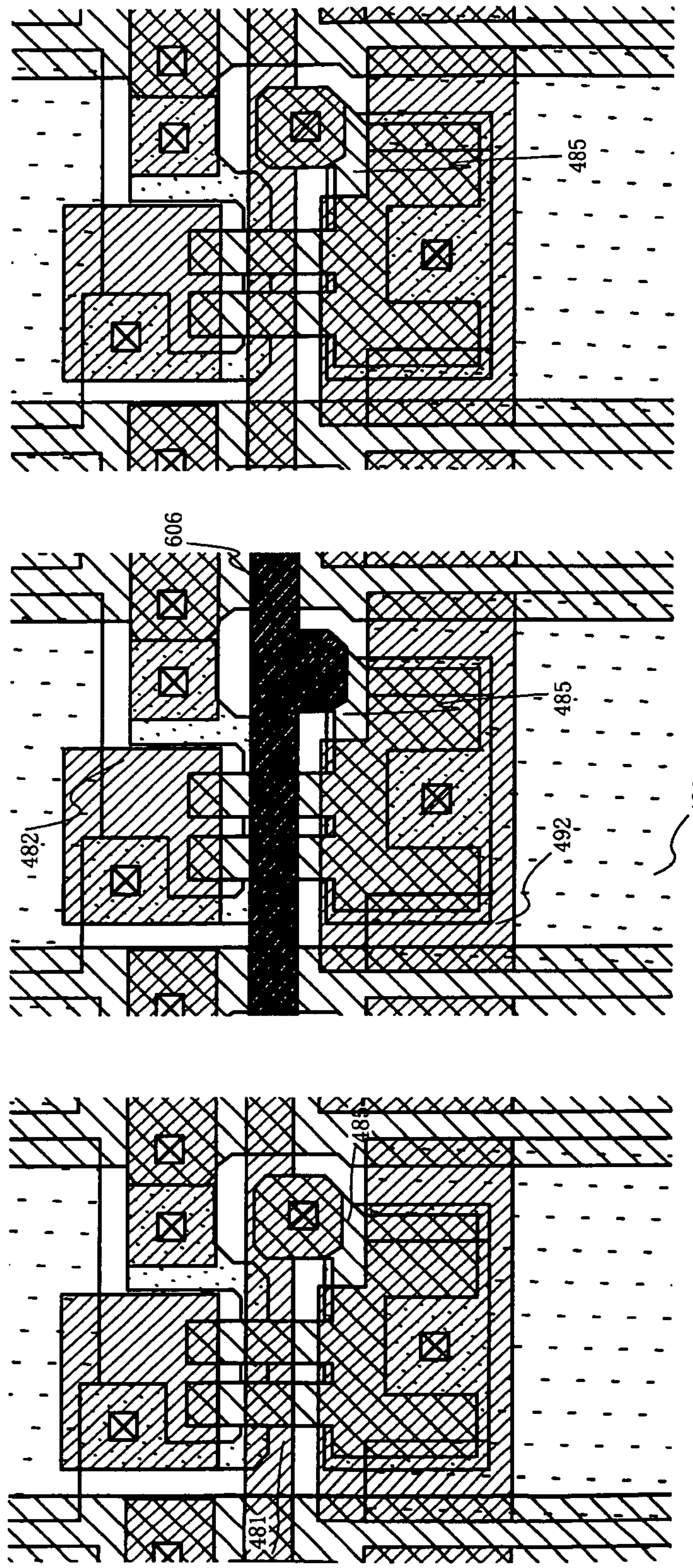
(B)
case wherein video voltage
of ±1V is applied

(C)
after drive pwoer source
is turned off



orientation of liquid crystal before reliability test
(liquid crystal ZLI4792)

【FIG. 13】



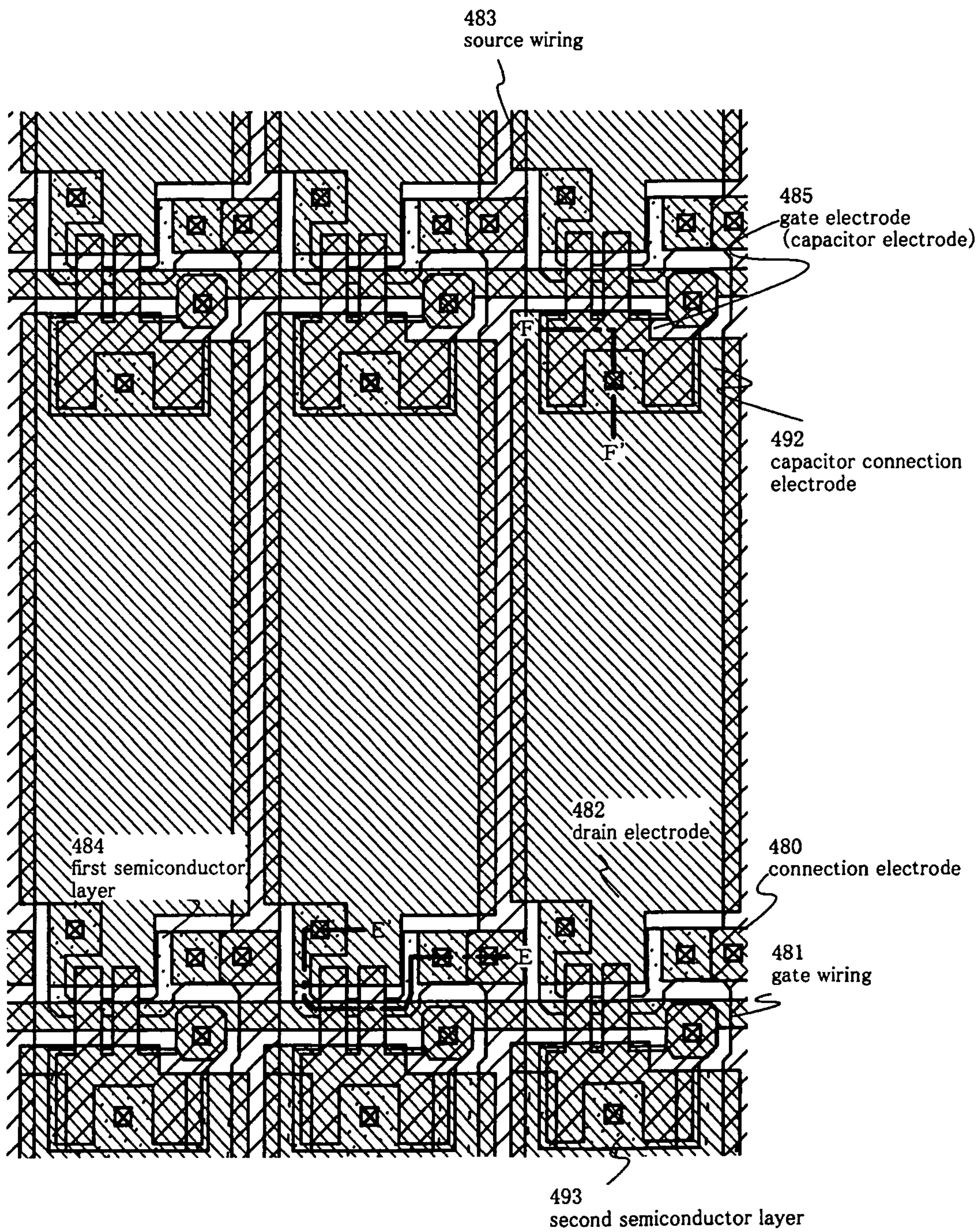
(A) before drive pp;ower source is turned on

(B) case wherein video voltage of ±1V is applied

(C) after drive power source is turned off

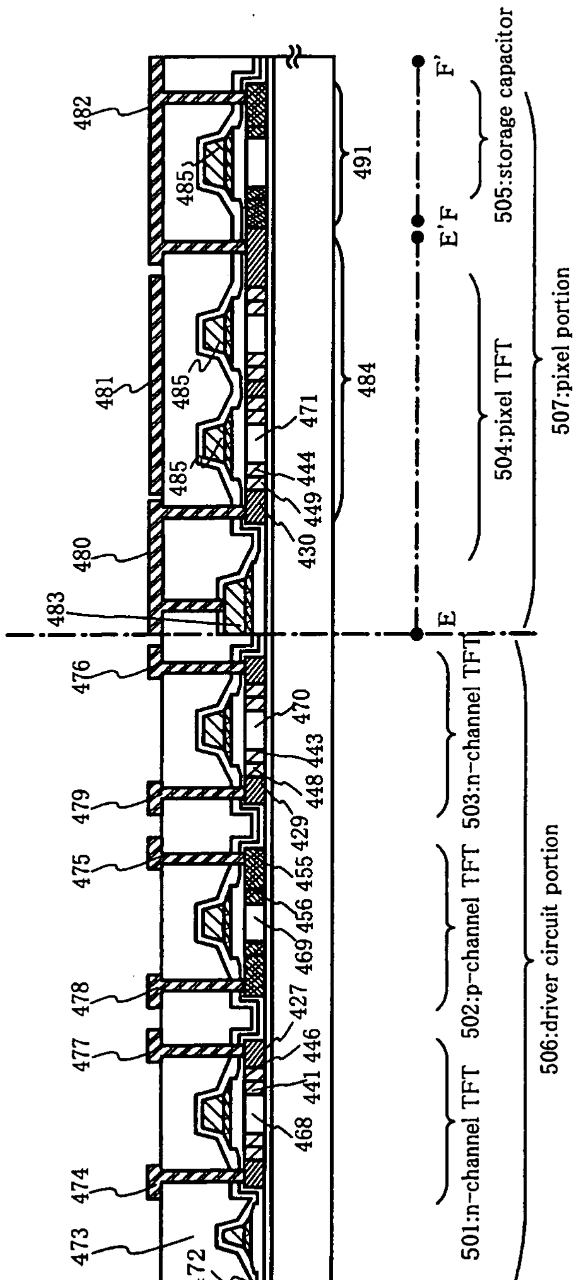
orientation of liquid crystal before reliability test (liquid crystal ZLI4792)

【FIG. 14】



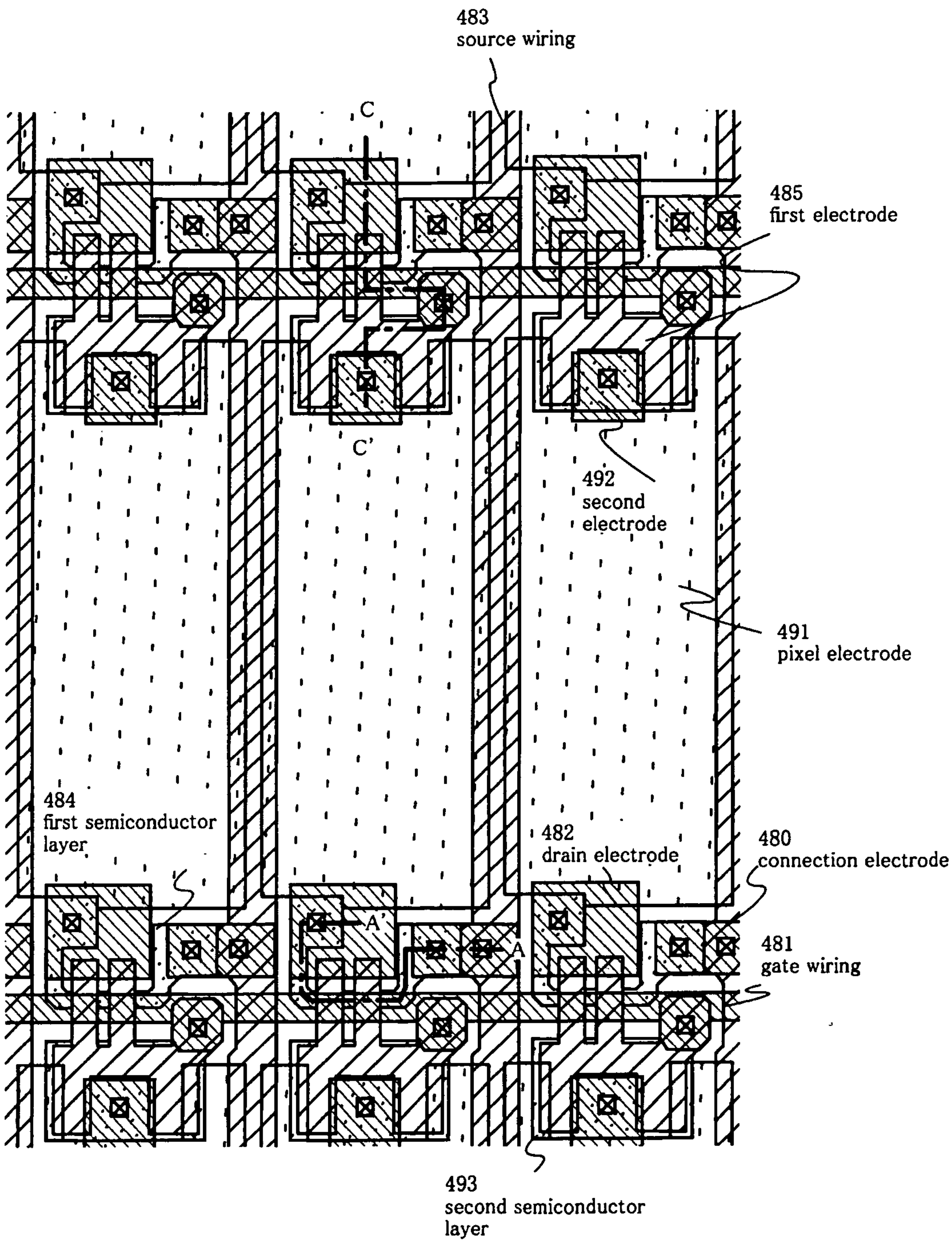
483
source wiring
485
gate electrode
(capacitor electrode)
F
F'
492
capacitor connection
electrode
482
drain electrode
484
first semiconductor
layer
480
connection electrode
F'
E
481
gate wiring
493
second semiconductor layer

[FIG. 15]

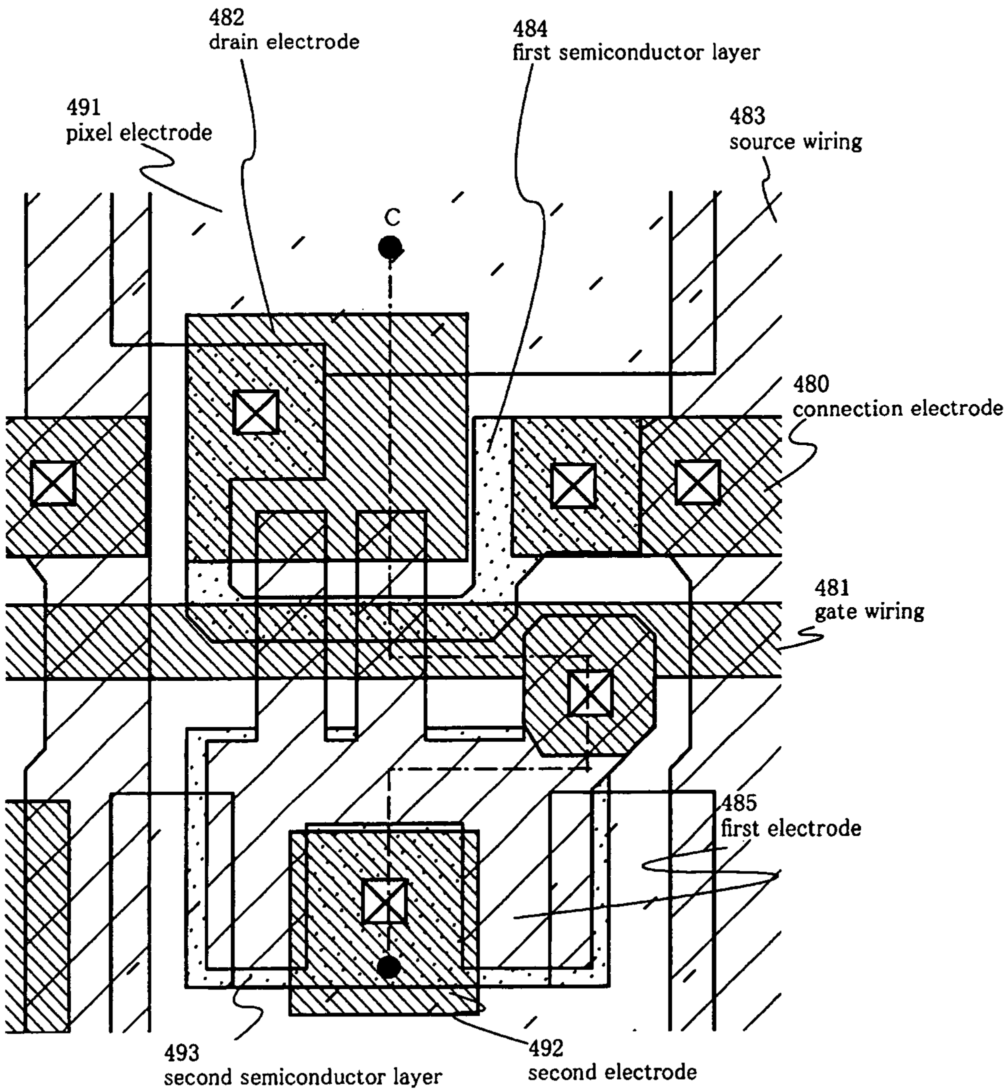


482
485
491
481
484
471
444
449
430
480
483
476
470
443
448
429
479
475
455
456
469
478
427
446
477
441
468
474
473
472
F'
E'F
E
505:storage capacitor
504:pixel TFT
507:pixel portion
503:n-channel TFT
502:p-channel TFT
501:n-channel TFT
506:driver circuit portion

【FIG. 16】

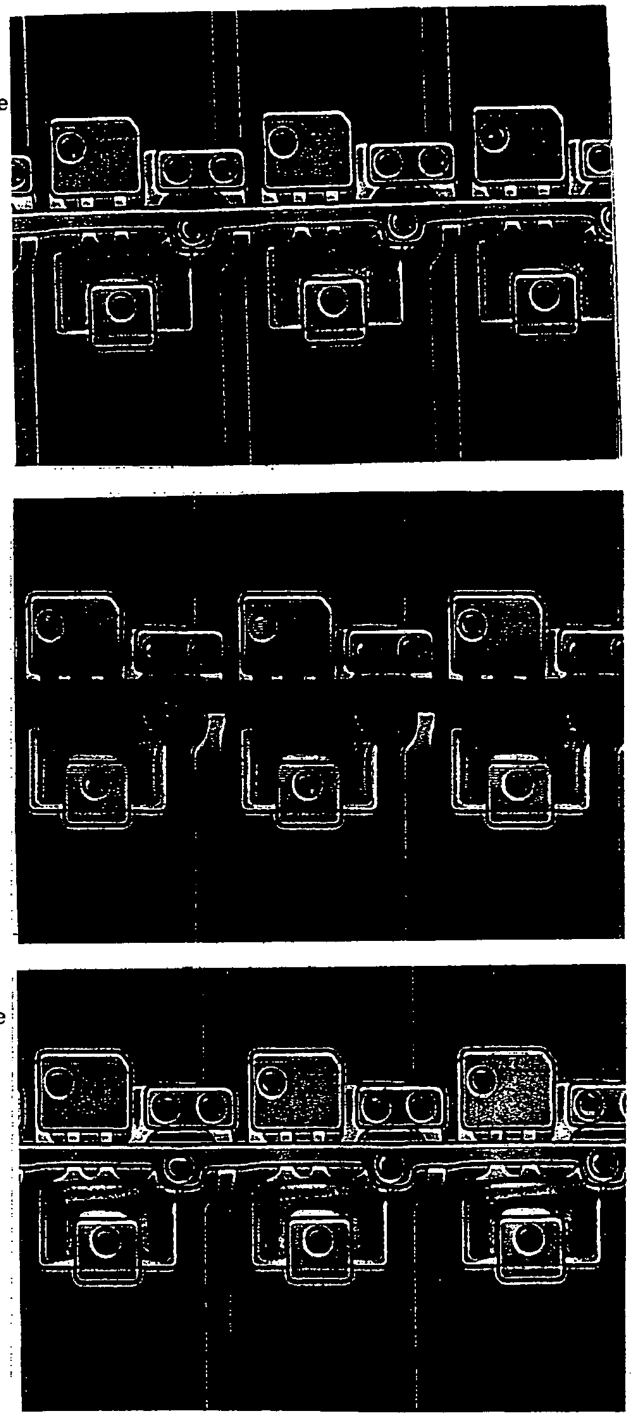

483
source wiring
C
485
first electrode
C'
492
second
electrode
491
pixel electrode
484
first semiconductor
layer
482
drain electrode
480
connection electrode
A'
A
481
gate wiring
493
second semiconductor
layer

【FIG. 17】



482
drain electrode
484
first semiconductor layer
491
pixel electrode
483
source wiring
C
480
connection electrode
481
gate wiring
485
first electrode
493
second semiconductor layer
492
second electrode

[FIG. 18]



(A)
soon after drive power source is turned off after 100 hours driving

(B)
case wherein video voltage of ±1V is applied

(C)
soon after drive power source is turned off

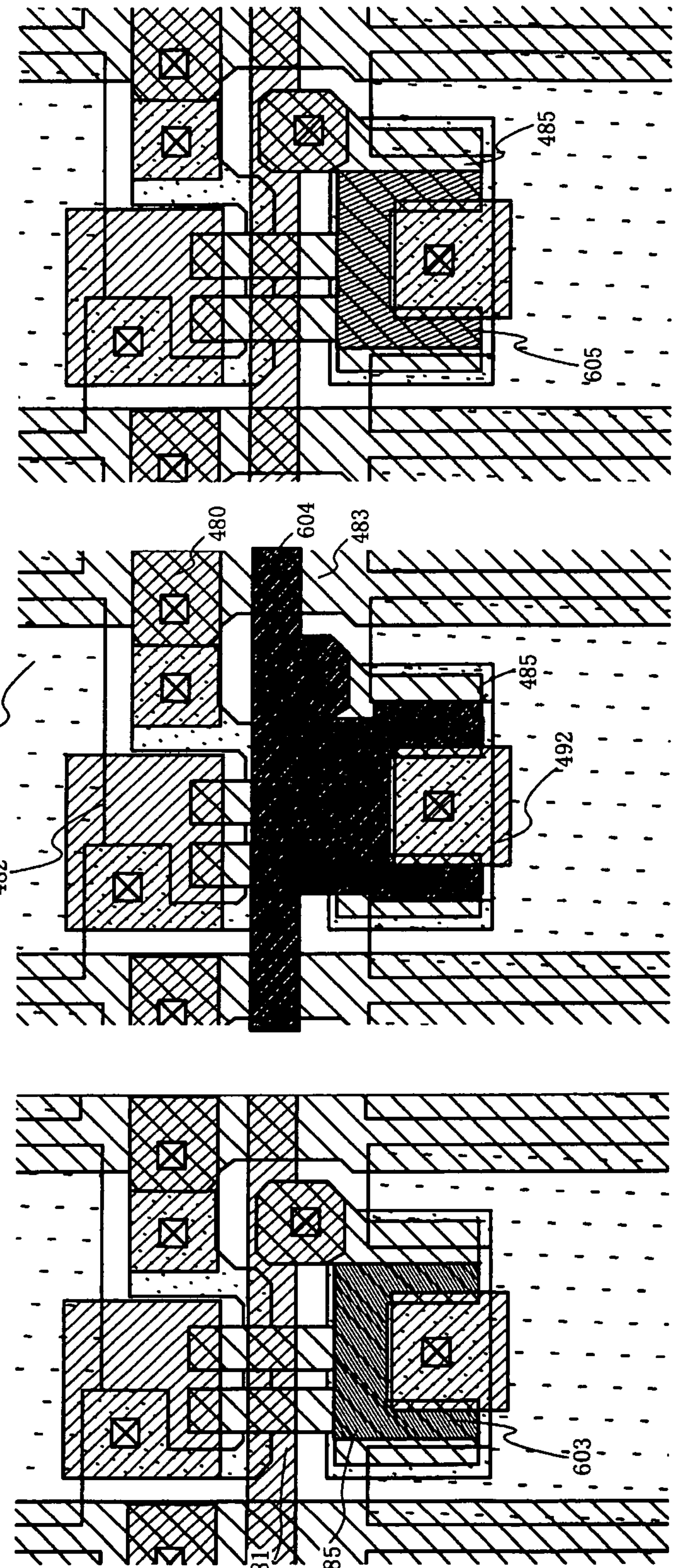
orientation of liquid crystal after relia bility test of 100 hours (85℃ ±5V after driving, liquid crystlal ZLI4792)

【FIG. 19】

(A) soon after drive power source is turned off after 100 hours driving

(B) case wherein video voltage of ±1V is applied

(C) soon after drive power source is turned off



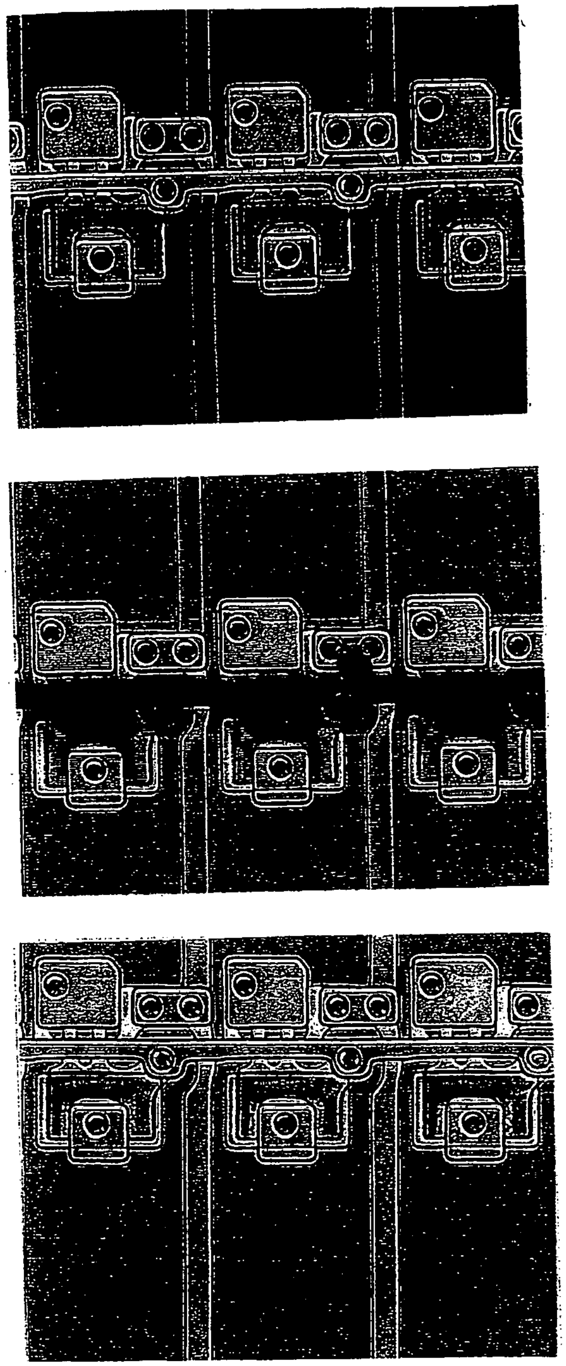
orientation of liquid crystal after reliability test of 100 hours
(85℃ ±5V after driving, liquid crystal ZLI4792)

【FIG. 20】

(A)
before drive power source
is turned on

(B)
case wherein video voltage
of ±1V is applied

(C)
after drive power source
is turned off



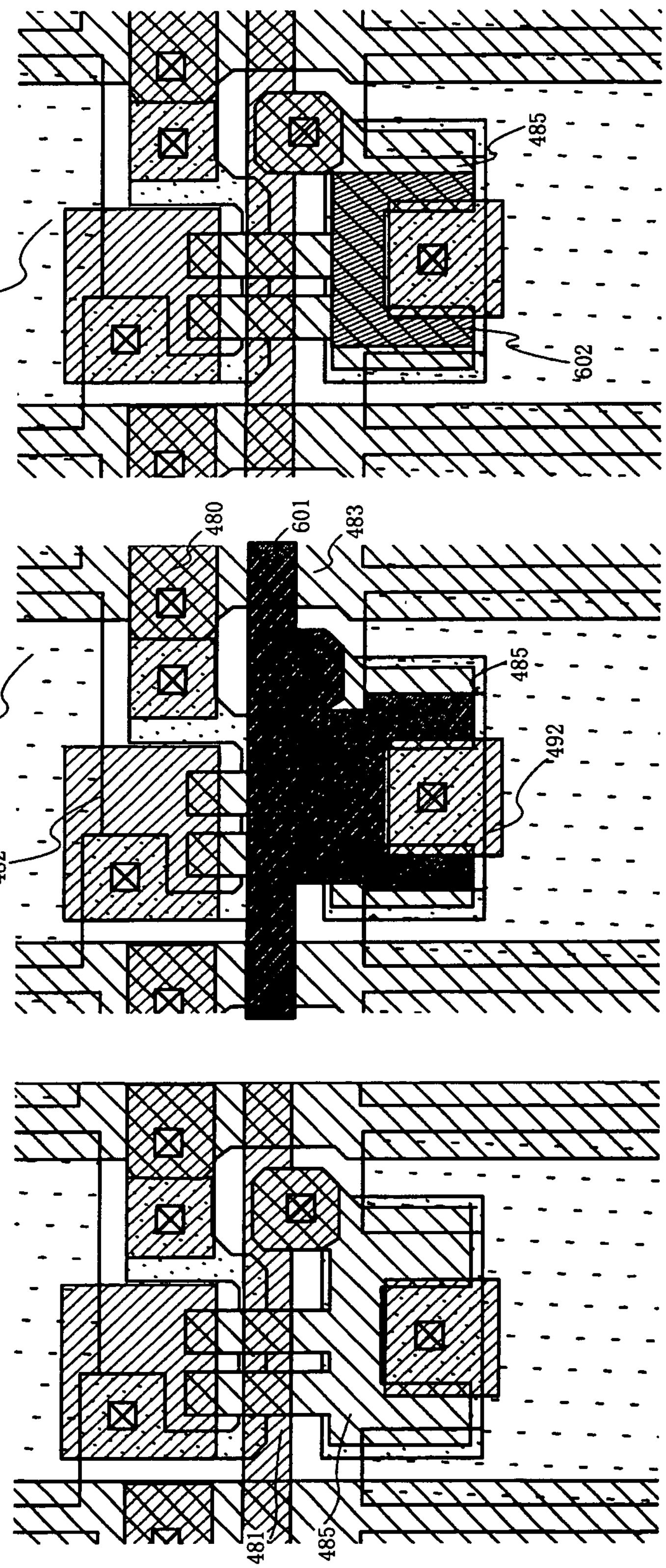
orientation of liquid crystal before reliability test
(liquid crystal ZLI4792)

【FIG. 21】

(A) before drive power source is turned on

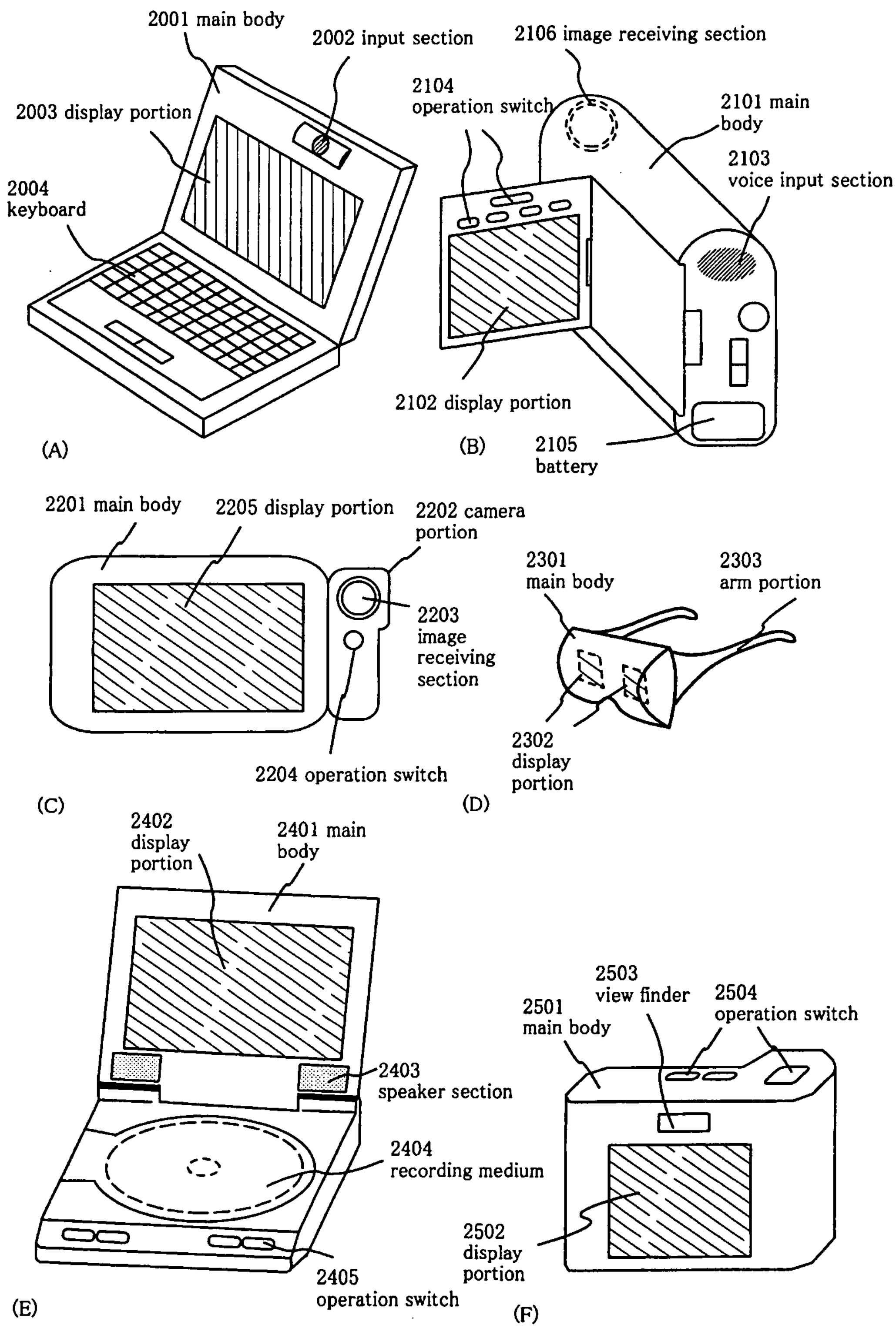
(B) case wherein video voltage of ±1V is applied

(C) after drive power source is turned off

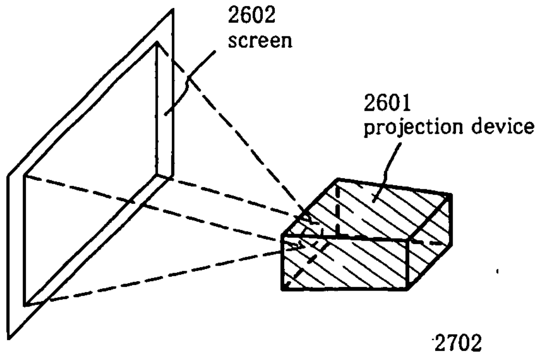


orientation of liquid crystal before reliability test
(liquid crystal ZLI4792

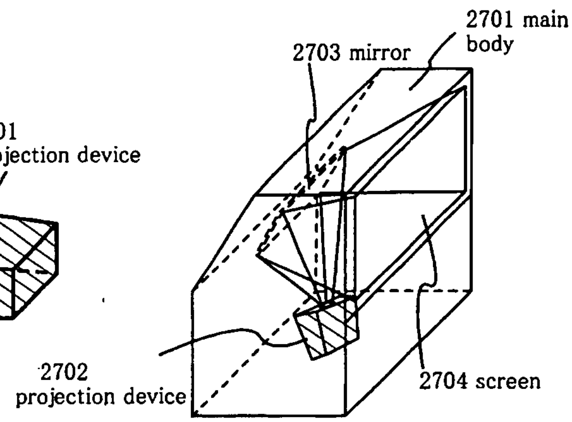
【FIG. 22】


2001 main body
2002 input section
2003 display portion
2004 keyboard
(A)
2106 image receiving section
2104 operation switch
2101 main body
2103 voice input section
2102 display portion
(B)
2105 battery
2201 main body
2205 display portion
2202 camera portion
2203 image receiving section
2204 operation switch
(C)
2301 main body
2303 arm portion
2302 display portion
(D)
2402 display portion
2401 main body
2403 speaker section
2404 recording medium
2405 operation switch
(E)
2503 view finder
2501 main body
2504 operation switch
2502 display portion
(F)

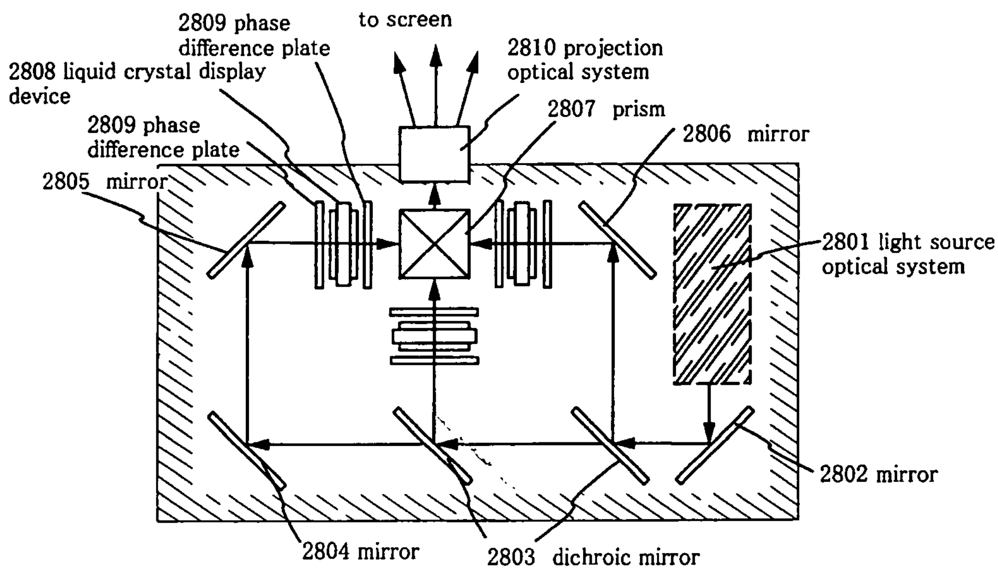
【FIG. 23】



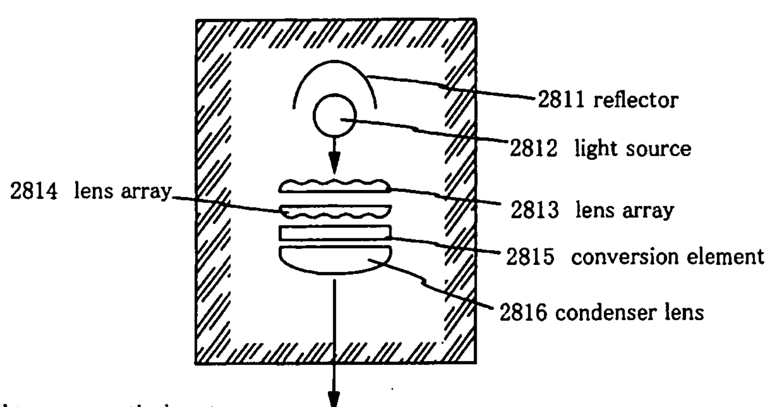
(A)



(B)

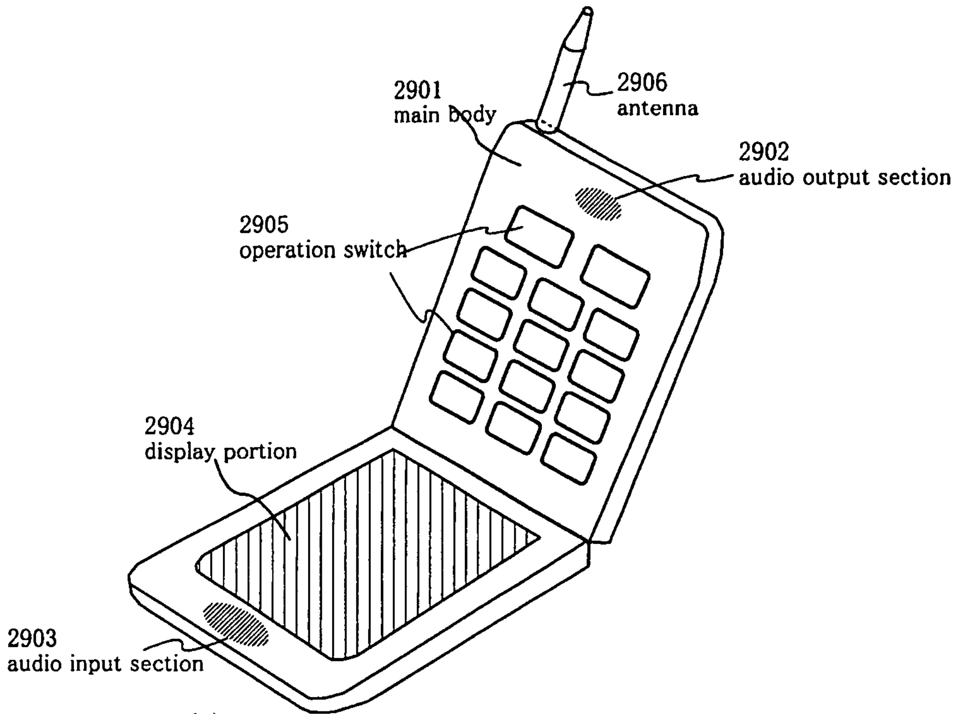


(C) projection device (three plates type)



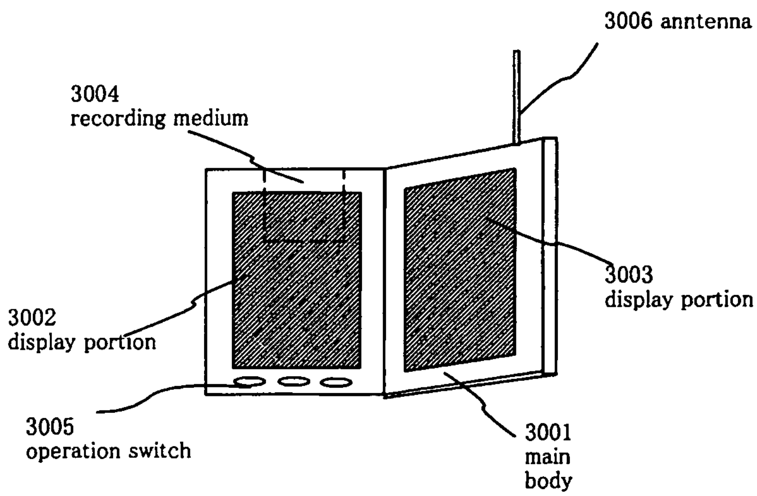
(D) light source optical system

【FIG. 24】



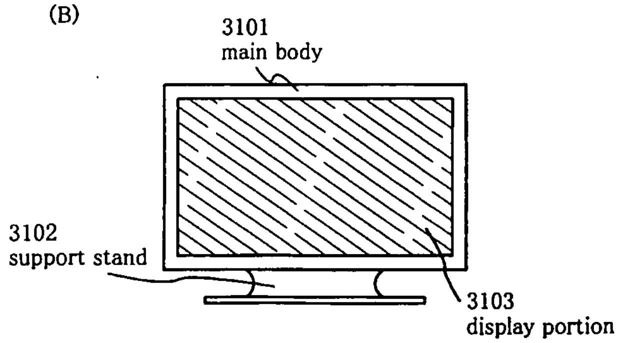
2901
main body
2906
antenna
2902
audio output section
2905
operation switch
2904
display portion
2903
audio input section

(A)



3006 anntenna
3004
recording medium
3003
display portion
3002
display portion
3005
operation switch
3001
main
body

(B)



3101
main body
3102
support stand
3103
display portion

(C)

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